MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. NOVEMBER 14, 1884. No. 1.

EDWIN DUNKIN, F.R.S., President, in the Chair.

Pietro Baracchi, the Observatory, Melbourne, Australia,

was duly elected a Fellow of the Society.

Prof. Th. Bredichin, Observatory, Moscow;
M. Magnus Nyrén, Observatory, Pulkowa; and
Prof. Edward S. Holden, Washburn Observatory, Madison, Wisconsin,

were duly elected Associates of the Society.

Extract from a Letter of M. Gogou to Prof. J. C. Adams on the Numerical Value of the Coefficient of Neison's Long Inequality in the Moon's Motion due to the Action of Mars.

(*Communicated by Prof. Adams.*)

En relisant la Note que M. Neison a publiée dans le vol. 42 No. 5 des *Monthly Notices* (Mars 1882, p. 266–268), j'ai vu qu'il s'appésantissait sur le fait que mes résultats ne s'étendent pas au-delà de la 3^{e} puissance et produits des excentricités de *Mars* et de la Terre. En parlant des termes dépendant des 5$^{\text{ièmes}}$ et 7$^{\text{ièmes}}$ puissances et produits des excentricités, il s'exprime comme il suit: "M. Gogou has entirely neglected these terms, *whereas in my investigation I retained them*" (p. 268). Or, comme j'ai déjà remarqué dans mon Mémoire que je vous ai envoyé dernièrement, il n'y a que dans les quantités qui multiplient les coefficients $[B_{\frac{7}{2}}]^{24}_{21}$, $[B_{\frac{7}{2}}]^{23}_{20}$ qu'il a conservé les termes en $e'^{/2}$, termes que moi je n'ai pas conservés dans mon calcul, pour les raisons que j'ai développées dans mon Mémoire.

En effet, M. Neison avait posé

$$R''' = \sigma m^2 a^4 \frac{a}{a''} \cdot \frac{r^3}{a^4} \left\{ \frac{15}{16} [(1 + 2\alpha^2 + 3e'''^2)[B_{\frac{7}{2}}]_{21}^{24} - (2 + \alpha^2 + 3e'''^2)\alpha [B_{\frac{7}{2}}]_{20}^{23} + \dots \right\}$$

tandis que moi j'ai posé

$$R''' = \sigma m^2 a^4 \frac{a}{a''} \cdot \frac{r^3}{a^4} \left\{ \frac{15}{16} [(1 + 2\alpha^2)[B_{\frac{7}{2}}]_{21}^{24} - (2 + \alpha^2)\alpha [B_{\frac{7}{2}}]_{20}^{23} + \dots \right\}$$

S'il s'agissait de tenir compte de deux termes en e'''^2 compris dans le développement donné par M. Neison, on devrait ajouter à la valeur de la partie (R) de la fonction perturbatrice R''', donnée dans mon Mémoire, une partie (R_2) telle qu'on ait

$$(R_2) = \frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{24}e'''^3) - 3\alpha e'''^2(B_{\frac{7}{2}}^{23}e'''^3)]\cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi''']$$

$$+ \frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{23}e''e'''^2) - 3\alpha e'''^2(B_{\frac{7}{2}}^{22}e''e'''^2)]\cos[\quad ,, \quad ,, \quad + \varpi'' + 2\varpi''']$$

$$+ \frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{22}e''^2e''') - 3\alpha e'''^2(B_{\frac{7}{2}}^{21}e''^2e''')]\cos[\quad ,, \quad ,, \quad + 2\varpi'' + \varpi''']$$

$$+ \frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{21}e'''^3) - 3\alpha e'''^3(B_{\frac{7}{2}}^{20}e'''^3)]\cos[\quad ,, \quad ,, \quad + 3\varpi'''],$$

laquelle, après la mise en nombres, se réduit à

$$\begin{aligned}(R_2) = &-12{,}133e'''^5 \cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''] \\ &+ 71{,}605e''e'''^4 \cos[\quad ,, \quad ,, \quad + \varpi'' + 2\varpi'''] \\ &- 146{,}246e''^2e'''^3 \cos[\quad ,, \quad ,, \quad + 2\varpi'' + \varpi'''] \\ &+ 102{,}315e''^3e'''^2 \cos[\quad ,, \quad ,, \quad + 3\varpi''],\end{aligned}$$

ou encore, en remplaçant e'''^2 par sa valeur $= (0{\cdot}093261\,6)^2$,

$$\begin{aligned}(R_2) = &-0{,}1055e'''^3 \cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''] \\ &+ 0{,}6228e''e'''^2 \cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + \varpi'' + 2\varpi''' \\ &- 1{,}2720e''^2e''' \cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 2\varpi'' + \varpi'''] \\ &+ 0{,}8899e''^3 \cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''].\end{aligned}$$

En ajoutant cette valeur à celle donnée dans mon Mémoire pour (R), on trouve

$$\begin{aligned}(R) + (R_2) = &+ 0{,}01e'''^3 \cos[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''] \\ &- 0{,}01e''e'''^2 \cos[\quad ,, \quad ,, \quad + \varpi'' + 2\varpi'''] \\ &- 0{,}21e''^2e''' \cos[\quad ,, \quad ,, \quad + 2\varpi'' + \varpi'''] \\ &+ 0{,}35e''^3 \cos[\quad ,, \quad ,, \quad + 3\varpi''].\end{aligned}$$

Ainsi donc, si l'on se bornait à rectifier seulement les erreurs dont est entaché le développement donné par M. Neison pour la fonction perturbatrice qui provient de l'action directe de *Mars*

sur la Lune, et si l'on s'arrêtait, dans ce développement, aux seuls termes conservés par lui, on trouverait

$$\begin{aligned}R''' = m''' \frac{a^3}{a''a'''^3}\Big\{ & 0{,}01e'''^3 \cos[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] \\ & -0{,}01e''e'''^2 \cos[(\quad ,, \quad ,, \quad +\varpi''+2\varpi'''] \\ & -0{,}21e''^2e''' \cos[\quad ,, \quad ,, \quad +2\varpi''+\varpi'''] \\ & +0{,}35e'''^3 \cos[\quad ,, \quad ,, \quad +3\varpi''']\Big\}.\end{aligned}$$

Substituant cette valeur dans l'équation qui donne la variation $\delta(\varpi+l)$ de la longitude moyenne de la Lune, on trouve pour l'inégalité qui nous occupe l'expression suivante

$$\begin{aligned}\delta(\varpi+l) = & -3m''' \frac{a}{a''a'''^3} \cdot \frac{1}{(n-24n''+20n''')^2} \\ & \times\{0{,}01e'''^3 \sin[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] \\ & -0{,}01e''e'''^2 \sin[\quad ,, \quad ,, \quad +\varpi''+2\varpi'''] \\ & -0{,}21e''^2e''' \sin[\quad ,, \quad ,, \quad +2\varpi''+\varpi'''] \\ & +0{,}35e'''^3 \sin[\quad ,, \quad ,, \quad +3\varpi''']\}.\end{aligned}$$

Si l'on désigne par σ le rapport de la masse de *Mars* à celle du Soleil, on aura

$$m''' = \sigma n''^2 a''^3 = \sigma n''^2 \alpha^3 a'''^3,$$

et, par suite,

$$\begin{aligned}\delta(\varpi+l) = & -3\sigma \frac{n''^2}{(n-24n''+20n''')^2} \alpha^3 \frac{a}{a''} \\ & \times\{0{,}01e'''^3 \sin[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] \\ & -0{,}01e''e'''^2 \sin[\quad ,, \quad ,, \quad +\varpi''+2\varpi'''] \\ & -0{,}21e''^2e''' \sin[\quad ,, \quad ,, \quad +2\varpi''+\varpi'''] \\ & +0{,}35e'''^3 \sin[\quad ,, \quad ,, \quad +3\varpi''')\}.\end{aligned}$$

En adoptant pour les lettres qui entrent dans cette formule les mêmes valeurs qu'a adoptés M. Neison, savoir

$$\sigma = \frac{1}{3{,}000{,}000} \qquad \frac{a}{a''} = 0{,}0025856 \qquad \log\alpha = \bar{1}{,}8171030$$

$$n = 17{,}325{,}594'',0 \qquad n'' = 1{,}295{,}977'',38 \qquad n''' = 689050{,}98$$

$$e'' = 0{,}01677106 \qquad e''' = 0{,}0932616$$

j'ai trouvé

$$\begin{aligned}\delta(\varpi+l) = & -0'',000206 \sin[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] \\ & +0'',000037 \sin[\quad ,, \quad ,, \quad +\varpi''+2\varpi'''] \\ & +0'',000140 \sin[\quad ,, \quad ,, \quad +2\varpi''+\varpi'''] \\ & -0'',000042 \sin[\quad ,, \quad ,, \quad +3\varpi'''],\end{aligned}$$

résultat tout-à-fait différent de celui publié par M. Neison dans les *Monthly Notices* du Novembre 1877.

Dans la Note que M. Neison a publiée dans les *Monthly Notices* du Mars 1882, il reconnaît d'ailleurs que la valeur trouvée par lui pour le coefficient de l'inégalité en question était beaucoup trop fort et que sa vraie valeur *doit être seulement d'une petite fraction de seconde*, au lieu de plusieurs secondes :—

Voici du reste textuellement le passage en question de la Note ci-dessus citée :

". . . the value found for the coefficient of this new term of long period was far too large. This fact I mentioned in my paper on Hansen's Terms of Long Period (*Monthly Notices*, March 1878, p. 269).

"Since then I have more accurately computed the value of this part of this term, and find its true value to be only a small fraction of a second, instead of several seconds."

J'ai cru nécessaire de rappeler ce passage de la Note de M. Neison, car je crois qu'à la suite d'une telle affirmation il n'y aurait plus lieu de se demander d'où provient l'énorme différence entre mon résultat et celui publié par M. Neison.

Dans une Note publiée dans le vol. 43 des *Monthly Notices*, p. 216, après constatation que mon résultat s'éléve à peine à $0''{\cdot}00034$, il y a en effet ce passage : "Il est difficile de voir d'où provient l'énorme différence entre ce résultat [le mien] et celui de M. Neison." Cette différence, d'après la déclaration même de M. Neison, tient, comme on le voit, à une erreur commise par lui dans les calculs.

Campulungu, Roumanie :
Le 9 Août, 1884.

The Proper Motions of the 460 Stars given in the R.A.S. Memoirs, vol. xxxiii., *when the Places of Auwers's Re-reduction of Bradley's Observations are adopted instead of Bessel's, with Notes on the Proper Motion of μ Piscium.* By E. J. Stone, M.A., F.R.S.

In the formation of my Cape Catalogue of 12,441, 1880, I adopted the usually accepted proper motions of the Bradley stars without any special examination.

For *μ Piscium* the values adopted from Main, *R.A.S. Memoirs*, vol. xix. p. 163, are R.A. $+0^{s}{\cdot}019$ and N.P.D. $+0''{\cdot}18$.

Recently I have thought it desirable to re-examine some of these adopted values by comparisons between the Southern Catalogues. By comparing the Cape Catalogue, 1840, with that for 1880, I find for *μ Piscium* the proper motions

R.A. $+0^{s}{\cdot}021$, N.P.D. $-0''{\cdot}01$.

The proper motion in R.A. agrees closely with the adopted value, but that in N.P.D. is utterly discordant.

A comparison between recent Northern observations and the Cape observations confirms the smallness of the proper motion in N.P.D. It appeared, therefore, that there must be something wrong in the declination given in Bessel's *Fundamenta*. A comparison between Auwers's re-reduction of Bradley's observations and the Cape Catalogue, 1880, gives

R.A. $+0^s.019$ and N.P.D. $+0''.02$.

The declinations for 1755 given by Bessel and Auwers differ $13''.17$.

It would appear, therefore, that the usually adopted value of the proper motion in R.A. $+0^s.019$ is sensibly correct; whilst the proper motion in N.P.D., instead of being equal to $+0''.18$, is very small indeed.

I have also examined the proper motions of σ *Ceti*, Bradley 356. In this case the proper motions given by the Cape Catalogues, 1840 and 1880, are

R.A. $-0^s.014$, N.P.D. $+0''.11$.

A comparison between Auwers's Bradley and the Cape, 1880, however, only gives

R.A. $-0^s.007$, N.P.D. $+0''.11$.

The difference $0^s.007$ in R.A. is, I believe, larger than can be due to errors in the places of the 1840 and 1880 Catalogues. The proper motion in R.A. is more probably $-0^s.012$ than $-0^s.007$.

In the case of τ^5 *Eridani*, Bradley 495, a comparison between the Cape Catalogues 1840 and 1880 gives the proper motions

R.A. $+0^s.004$, N.P.D. $+0''.03$.

The values usually adopted have been

R.A. $-0^s.003$, N.P.D. $+0''.03$.

The discordance in sign in the proper motion in R.A. disappears if we adopt Auwers's re-reduction, we thus find that the Cape, 1880, and Bradley then give

R.A. $+0^s.002$, N.P.D. $+0''.03$.

As a general rule, however, the agreement between the determinations of the proper motions from the Greenwich observations and Bessel's Bradley, and those from the Cape observations, is exceedingly close.

I have added the proper motions of the 460 stars which I deduced some years ago from a comparison between the Greenwich Catalogue, 1860, and Bessel's *Fundamenta*, where Auwers's places are used instead of Bessel's for Bradley's results.

Peters's constants have been adopted as before.

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
3220	22 Andromedæ	+0·002	+0·01
3222	6 Ceti	−0·007	+0·26
6	Bradley 6	—	+0·03
36	11 Ceti	+0·012	+0·05
40	14 Cassiopeiæ λ	+0·003	+0·02
46	16 Cassiopeiæ	−0·002	+0·01
67	20 Cassiopeiæ π	−0·002	+0·02
71	17 Ceti φ′	−0·002	+0·11
72	23 Cassiopeiæ	—	+0·03
80	60 Piscium	0·000	0·00
83	25 Cassiopeiæ ν	+0·003	0·00
104	38 Andromedæ η	−0·002	+0·04
92	2 Ursæ Minoris	+0·068	+0·01
129	41 Andromedæ	+0·014	+0·07
150	84 Piscium χ	0·000	−0·01
177	46 Andromedæ ξ	+0·003	−0·01
185	93 Piscium ρ	−0·005	−0·03
189	94 Piscium	+0·002	+0·03
211	101 Piscium	−0·001	0·00
217	Bradley 217	+0·008	—
223	105 Piscium	+0·004	0·00
229	107 Piscium	−0·021	+0·66
231	109 Piscium	−0·005	+0·06
262	8 Arietis ι	+0·001	+0·01
271	112 Piscium	+0·014	+0·25
273	59 Ceti υ	+0·007	+0·02
296	15 Arietis	+0·006	+0·03
299	6 Persei	+0·036	+0·20
317	8 Trianguli δ	+0·091	+0·23
329	68 Ceti ο	−0·002	+0·22
348	Bradley 348	−0·004	−0·01
363	79 Ceti	−0·012	+0·43
364	31 Arietis	+0·018	+0·07
375	83 Ceti ε	+0·006	+0·25
366	Bradley 366	+0·001	+0·04
381	Bradley 381	−0·001	+0·03
390	1 Eridani τ^1	+0·022	−0·05
393	40 Arietis	+0·003	+0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
394	16 Persei	+0·017	+0·06
404	2 Eridani τ^2	−0·006	+0·02
423	5 Eridani	0·000	0·00
429	25 Persei ρ	+0·011	+0·10
435	10 Eridani ρ^3	+0·004	−0·01
431	Bradley 431	—	+0·07
448	Bradley 448	—	+0·02
461	95 Ceti	+0·016	+0·06
468	97 Ceti κ^2	+0·002	+0·03
478	34 Persei	+0·001	+0·07
471	Bradley 471	—	+0·06
487	17 Eridani	0·000	0·00
489	6 Tauri t	+0·002	+0·04
507	14 Tauri	+0·008	+0·04
518	25 Eridani	+0·002	−0·02
529	30 Tauri e	+0·001	+0·02
530	27 Eridani τ^6	−0·013	+0·54
536	Bradley 536	—	+0·02
540	32 Eridani	+0·003	0·00
541	33 Tauri	+0·005	—
553	38 Tauri ν	0·000	+0·01
558	41 Tauri	+0·002	+0·05
562	43 Tauri ω^1	+0·007	+0·03
570	46 Tauri	−0·002	−0·02
576	51 Tauri	+0·007	+0·03
582	52 Tauri ϕ	−0·001	+0·05
588	59 Tauri χ^1	+0·001	+0·02
599	65 Tauri κ^1	+0·005	+0·06
606	72 Tauri υ^2	0·000	0·00
620	81 Tauri	+0·008	—
618	57 Persei m	+0·001	+0·01
624	45 Eridani	0·000	+0·01
631	46 Eridani	0·000	+0·01
636	50 Eridani υ^6	−0·010	+0·28
650	Bradley 650	+0·007	+0·12
657	57 Eridani μ	0·000	0·00
675	5 Orionis	+0·001	+0·01
680	8 Orionis	0·000	0·00

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
677	3 Aurigæ ι	0·000	0·00
686	Bradley 686	0·000	—
695	10 Orionis π^6	0·000	−0·01
697	63 Eridani	+0·001	+0·12
701	65 Eridani ψ	−0·002	−0·02
698	102 Tauri ι	+0·004	+0·05
713	2 Leporis ϵ	+0·002	+0·08
706	103 Tauri	0·000	—
712	66 Eridani	0·000	+0·02
727	3 Leporis ι	0·000	0·00
725	17 Orionis ρ	0·000	0·00
765	28 Orionis η	−0·001	−0·01
758	24 Aurigæ ϕ	−0·001	+0·04
767	115 Tauri	0·000	0·00
790	121 Tauri	+0·001	+0·02
792	37 Orionis ϕ^1	−0·001	+0·01
843	14 Leporis ζ	−0·001	−0·01
858	15 Leporis δ	+0·017	+0·66
869	59 Orionis	+0·002	+0·01
878	64 Orionis χ^3	—	+0·02
885	66 Orionis	−0·002	+0·01
892	18 Leporis θ	−0·001	−0·02
902	2 Lyncis	+0·001	−0·03
916	73 Orionis k^1	0·000	0·00
920	5 Monocerotis	−0·001	—
928	7 Monocerotis	0·000	−0·01
945	9 Monocerotis	−0·001	−0·01
953	19 Geminorum	−0·001	0·00
957	12 Monocerotis	−0·004	−0·01
978	7 Canis Majoris ν^2	+0·004	+0·05
970	54 Aurigæ	−0·001	+0·02
981	15 Monocerotis	+0·001	0·00
986	28 Geminorum	−0·001	+0·01
984	57 Aurigæ	−0·003	+0·01
990	32 Geminorum	−0·001	−0·03
995	18 Monocerotis	—	+0·01
997	33 Geminorum	−0·002	−0·09
1004	36 Geminorum *d*	0·000	+0·04

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1007	37 Geminorum	−0·004	−0·02
1009	38 Geminorum *e*	+0·004	+0·07
1030	45 Geminorum	−0·002	+0·09
1041	20 Monocerotis	+0·006	−0·22
1038	48 Geminorum	−0·003	+0·03
1047	22 Monocerotis	−0·001	−0 03
1044	Piazzi vii.-11	—	−0·03
1050	53 Geminorum	−0·002	0 00
1055	24 Monocerotis	−0·001	−0·01
1059	27 Canis Majoris	−0·001	−0·05
1080	64 Geminorum b^1	−0·003	+0·05
1082	65 Geminorum b^2	−0·001	+0·01
1110	26 Monocerotis γ	−0·007	+0·02
1134	9 Puppis	−0·006	+0·34
1139	14 Canis Minoris	−0·012	−0·09
1140	2 Cancri ω^1	−0·001	−0·02
1153	Bradley 1153	−0·002	−0·13
1161	10 Cancri μ^2	+0·002	+0·05
1174	16 Puppis	0·000	−0·01
1179	20 Puppis	−0·001	+0·01
1181	18 Cancri χ	−0·001	+0·37
1197	Piazzi viii.-69	−0·004	−0·02
1195	2 Ursæ Majoris A	−0·009	+0·07
1213	36 Cancri c^1	−0·004	+0·01
1211	Piazzi viii.-110	−0·002	+0·01
1221	5 Hydræ σ	−0·004	0 00
1232	45 Cancri A^1	−0·001	−0·02
1235	7 Hydræ η	−0·002	−0·01
1239	48 Cancri ι	−0·001	+0·03
1248	13 Hydræ ρ	−0·002	+0·02
1254	55 Cancri ρ^2	−0·038	+0·23
1284	18 Hydræ ω	−0 001	−0·01
1280	15 Ursæ Majoris *f*	−0·013	+ ·
1279	14 Ursæ Majoris τ	+0 015	+0·07
1286	75 Cancri	−0·009	+0·37
1298	81 Cancri π^1	−0 038	−0·27
1299	Bradley 1299	0·000	+0·02
1300	Bradley 1300	−0 012	−0·05

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1303	22 Hydræ θ	+0·009	+0·30
1304	82 Cancri π^2	−0·002	−0·03
1307	23 Hydræ	−0·001	−0·02
1318	Bradley 1318	−0·010	−0·01
1320	1 Leonis κ	−0·002	+0·03
1327	29 Hydræ	−0·003	0·00
1328	2 Leonis ω	+0·003	−0·02
1337	9 Leonis Minoris	+0·002	+0·05
1340	10 Leonis Minoris	+0·001	0·00
1343	11 Leonis Minoris	−0·059	+0·25
1344	33 Hydræ	0·000	+0·03
1346	42 Lyncis	−0·001	−0·02
1349	10 Leonis	−0·005	−0·02
1356	35 Hydræ ι	+0·002	+0·06
1362	38 Hydræ κ	−0·001	−0·02
1372	19 Leonis	−0·006	−0·04
1373	Bradley 1373	−0·002	—
1380	4 Sextantis	−0·009	+0·02
1388	39 Hydræ v^1	−0·001	+0·01
1386	7 Sextantis	−0·013	−0·14
1394	26 Leonis	−0·004	0·00
1397	20 Leonis Minoris	−0·040	+0·43
1407	15 Sextantis	—	−0·03
1409	16 Sextantis	−0·001	−0·01
1412	41 Hydræ λ	−0·014	+0·06
1425	36 Leonis ζ	+0·001	−0·02
1435	23 Sextantis	−0·001	−0·02
1429	Bradley 1429	—	+0·01
1444	29 Leonis Minoris	−0·009	+0·06
1445	30 Leonis Minoris	−0·006	+0·05
1439	Bradley 1439	—	−0·01
1459	30 Sextantis	−0·002	+0·01
1463	46 Leonis i	−0·003	−0·03
1465	34 Leonis Minoris	−0·005	−0·01
1458	Bradley 1458	+0·012	0·00
1475	37 Leonis Minoris	0·000	−0·04
1479	Hydræ ϕ^3	−0·009	−0·05
1490	42 Leonis Minoris	−0·003	+0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1509	46 Leonis Minoris	+0·006	+0·25
1514	Bradley 1514	—	+0·03
1515	54 Leonis (1st star)	−0·006	−0·02
1517	55 Leonis	+0·006	−0·02
1522	47 Ursæ Majoris	−0·027	—
1530	61 Leonis p^1	+0·001	0·00
1529	60 Leonis b	−0·002	−0·05
1533	62 Leonis p^2	−0·006	−0·02
1536	9 Crateris	−0·016	+0·02
1538	Bradley 1538	+0·001	+0·02
1544	10 Crateris	−0·006	−0·03
1549	72 Leonis	−0·003	−0·01
1563	14 Crateris ϵ	−0·004	−0·05
1565	81 Leonis	—	0·00
1573	85 Leonis	−0·003	+0·03
1574	58 Ursæ Majoris	−0·005	−0·08
1577	88 Leonis	−0·024	+0·18
1582	89 Leonis	−0·012	+0·08
1581	2 Draconis	+0·014	+0·11
1590	1 Virginis ω	−0·001	+0·01
1593	61 Ursæ Majoris	−0·001	+0·39
1595	3 Draconis	−0·005	−0·03
1620	1 Comæ	−0·004	+0·01
1624	1 Corvi α	+0·005	+0·04
1630	4 Comæ	−0·003	+0·03
1639	6 Comæ	−0·006	0·00
1641	7 Comæ	−0·004	−0·01
1645	8 Comæ	−0·003	0·00
1650	Bradley 1650	—	−0·01
1654	11 Comæ	−0·009	−0·09
1658	12 Comæ	−0·001	−0·01
1661	13 Comæ	−0·001	+0·01
1665	14 Comæ	−0·002	+0·01
1666	15 Comæ	−0·007	+0·08
1667	16 Comæ	−0·001	0·00
1680	4 Draconis	—	+0·07
1681	8 Corvi η	−0·032	+0·05
1690	25 Virginis f	−0·003	+0·02

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1694	26 Virginis χ	−0·006	+0·02
1700	28 Virginis	0·000	+0·03
1701	30 Virginis ρ	+0·004	+0·08
1703	76 Ursæ Majoris	—	+0·03
1706	33 Virginis	+0·019	+0·45
1710	36 Virginis	+0·002	+0·01
1712	11 Canum Venaticorum	—	0·00
1727	8 Draconis	—	+0·05
1728	36 Comæ	−0·003	−0·05
1729	44 Virginis *k*	−0·003	−0·02
1732	46 Virginis	−0·003	−0·07
1733	37 Comæ	−0·002	0·00
1738	48 Virginis	−0·004	0·00
1740	39 Comæ	−0·006	+0·05
1744	45 Hydræ ψ	−0·004	+0·04
1746	50 Virginis	0·000	+0·01
1757	56 Virginis	−0·003	+0·04
1760	59 Virginis *e*	−0·023	−0·20
1761	58 Virginis	−0·007	−0·03
1762	60 Virginis σ	−0·003	−0·03
1767	21 Canum Venaticorum	−0·004	0 00
1766	62 Virginis	−0·010	−0·01
1772	65 Virginis	−0·004	−0·01
1773	66 Virginis	+0·010	+0·02
1775	68 Virginis *i*	−0·011	+0·02
1780	70 Virginis	−0·020	+0·57
1782	72 Virginis l^1	+0·002	−0·04
1783	73 Virginis	−0·008	+0·01
1786	76 Virginis *h*	−0·005	+0·02
1790	80 Virginis	0·000	−0·10
1793	81 Virginis	−0 002	—
1801	83 Virginis	+0·001	0·00
1804	85 Virginis	−0·006	+0·03
1806	87 Virginis	+0·001	+0·03
1826	9 Boötis	+0·001	+0·05
1858	103 Virginis	−0·006	0·00
1862	52 Hydræ	−0·003	+0·05
1865	105 Virginis φ	−0·009	−0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1868	24 Boötis g	−0·032	+0·07
1877	31 Boötis	+0·001	+0·02
1883	34 Boötis	−0·001	0·00
1888	35 Boötis	−0·005	+0·05
1895	Bradley 1895	−0·007	—
1896	10 Libræ	−0·005	−0·01
1906	6 Ursæ Minoris	—	−0·02
1899	12 Libræ	−0·001	+0·04
1914	40 Boötis	—	−0·05
1915	110 Virginis	−0·004	−0·02
1920	22 Libræ ν^2	−0·008	+0·01
1924	45 Boötis	+0·012	+0·19
1928	25 Libræ	−0·005	+0·03
1935	48 Boötis χ	−0·026	−0·03
1965	52 Boötis ν^1	+0·001	+0·01
1967	53 Boötis ν^2	−0·003	+0·01
1968	4 Coronæ θ	−0·005	—
1986	21 Serpentis ι	−0·006	+0·03
1991	8 Coronæ γ	−0·008	+0·04
1994	9 Coronæ π	—	0·00
2010	10 Coronæ δ	−0·009	+0·07
2013	38 Serpentis ρ	−0·004	−0·02
2018	11 Coronæ κ	−0·002	+0·36
2021	1 Herculis χ	+0·037	−0·62
2037	15 Coronæ ρ	—	+0·78
2038	44 Serpentis π	0·000	−0·04
2058	16 Coronæ τ	−0·006	−0·33
2061	11 Herculis ϕ	—	−0·03
2081	50 Serpentis σ	+0·010	−0·04
2087	19 Coronæ ξ	—	−0·12
2083	5 Ophiuchi ρ	−0·003	+0·01
2089	23 Herculis	—	+0·02
2090	24 Herculis ω	—	+0·03
2093	25 Herculis	0·000	+0·01
2104	14 Draconis η	—	−0·04
2105	29 Herculis h	−0·014	+0·07
2108	12 Ophiuchi	+0·026	+0·30
2116	36 Herculis m^1	−0·001	−0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
2117	37 Herculis m^2	−0·002	+0·01
2125	39 Herculis	−0·001	+0·04
2130	41 Herculis	−0·017	—
2131	43 Herculis i	0·000	−0·04
2139	47 Herculis k	+0·002	−0·01
2145	50 Herculis	−0·004	−0·01
2153	Bradley 2153	−0·002	—
2155	26 Ophiuchi	−0·003	+0·08
2167	60 Herculis	+0·004	−0·01
2178	37 Ophiuchi	0·000	+0·03
2184	41 Ophiuchi	−0·004	+0·06
2195	69 Herculis e	−0·002	−0·08
2188	Bradley 2188	−0·005	+0·07
2192	43 Ophiuchi	0·000	+0·03
2220	57 Ophiuchi μ	−0·002	+0·01
2225	56 Serpentis o	−0·005	+0·02
2240	29 Draconis	—	−0·05
2230	3 Sagittarii	−0·002	+0·02
2239	87 Herculis	0·000	+0·03
2254	57 Serpentis ζ	+0·009	+0·04
2265	69 Ophiuchi τ	+0·002	+0·01
2269	96 Herculis	−0·001	+0·01
2271	70 Ophiuchi	+0·016	+1·10
2337	44 Draconis χ	+0·117	+0·39
2324	24 Sagittarii	−0·005	+0·01
2326	25 Sagittarii	+0·009	−0·03
2342	2 Aquilæ	0·000	0·00
2357	6 Lyræ ζ^1	+0·003	−0·02
2358	Lyræ ζ^2	+0·003	−0·02
2380	11 Lyræ δ^1	−0·001	·00
2383	12 Lyræ δ^2	−0·002	−0·01
2404	50 Draconis	−0·016	−0·07
2409	Bradley 2409	—	−0·02
2427	20 Lyræ η	0·000	−0·01
2443	55 Draconis	—	−0·01
2428	1 Vulpeculæ	0·000	0·00
2446	49 Sagittarii χ^3	−0·003	0·00
2471	58 Draconis π	—	−0·03

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
2477	37 Aquilæ κ	0·000	0·00
2484	41 Aquilæ ι	0·000	0·00
2498	13 Cygni θ	−0·002	−0·24
2499	6 Sagittæ β	0·000	+0·04
2503	14 Cygni	+0·002	−0·05
2514	15 Cygni	+0·006	−0·04
2517	17 Cygni χ	0·000	+0·44
2518	52 Aquilæ π	0·000	0·00
2523	8 Sagittæ ζ	+0·003	−0·04
2537	13 Vulpeculæ	+0·001	−0·04
2548	21 Cygni η	−0·003	+0·03
2553	14 Vulpeculæ	−0·007	−0·02
2559	Bradley 2559	0·000	0·00
2568	15 Sagittæ	−0·029	+0·37
2591	4 Capricorni	+0·001	+0·03
2602	23 Vulpeculæ	−0·004	−0·01
2606	24 Vulpeculæ	+0·001	+0·03
2612	32 Cygni	+0·001	0·00
2625	39 Cygni	+0·004	−0·01
2633	69 Aquilæ	+0·003	−0·01
2637	41 Cygni	+0·001	0·00
2645	45 Cygni ω^2	+0·001	−0·01
2642	2 Delphini ϵ	0·000	+0·03
2647	46 Cygni ω^3	+0·002	+0·05
2651	2 Cephei θ	+0·005	+0·05
2657	15 Capricorni υ	−0·003	−0·01
2662	8 Delphini θ	−0·001	+0·01
2682	73 Draconis	+0·001	+0·02
2704	75 Draconis	+0·009	−0·01
2692	54 Cygni λ	−0·002	−0·01
2693	15 Delphini	+0·002	−0·10
2700	19 Capricorni	−0·005	+0·01
2720	Bradley 2720	—	−0·03
2713	20 Capricorni	+0·001	+0·02
2727	Bradley 2727	—	+0·03
2718	21 Capricorni	−0·003	−0·01
2748	Bradley 2748	—	−0·05
2737	24 Capricorni A	−0·003	+0·02

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
2747	13 Aquarii ν	+0·005	0·00
2751	5 Equulei γ	+0·004	+0·17
2758	28 Capricorni ϕ	+0·009	0·00
2761	7 Equulei δ	+0·011	+0·29
2769	67 Cygni σ	0·000	+0·02
2773	Bradley 2773	−0·002	—
2776	17 Aquarii	−0·004	+0·02
2788	6 Cephei	0·000	+0·01
2782	19 Aquarii	−0·001	+0·17
2805	7 Cephei	−0·002	+0·03
2813	4 Pegasi	+0·007	−0·04
2820	42 Capricorni	−0·013	+0·30
2819	41 Capricorni	+0·007	+0·11
2823	44 Capricorni	−0·002	−0·03
2834	46 Capricorni c^1	−0·003	−0·02
2837	9 Pegasi	+0·002	0·00
2842	Piscis Australis θ	−0·006	0·00
2859	14 Pegasi	+0·001	+0·03
2864	16 Pegasi	0·000	0·00
2873	12 Piscis Australis η	0·000	0·00
2883	31 Aquarii o	0·000	0·00
2891	22 Pegasi ν	+0·006	−0·11
2906	18 Cephei	+0·001	—
2907	17 Cephei ξ	—	−0·07
2908	37 Aquarii e^1	+0·003	−0·05
2909	38 Aquarii e^2	+0·002	−0·01
2922	16 Piscis Australis λ	+0·001	+0·03
2933	1 Lacertæ	+0·001	0·00
2936	45 Aquarii	+0·004	0·00
2941	30 Pegasi	0·000	0·00
2940	47 Aquarii	−0·003	+0·07
2944	31 Pegasi	0·000	−0·01
2949	50 Aquarii	+0·002	−0·02
2958	4 Lacertæ	−0·002	+0·02
2959	35 Pegasi	+0·004	+0·30
2969	26 Cephei	−0·003	+0·02
2970	5 Lacertæ	−0·002	+0·02
2967	58 Aquarii	+0·004	+0·02

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
2971	6 Lacertæ	−0·002	−
2980	28 Cephei	−0·009	+0·07
2976	59 Aquarii *v*	+0·015	+0·16
2988	29 Cephei *ρ*	—	+0·03
2995	11 Lacertæ	+0·008	−0·01
2991	19 Piscis Australis	−0·002	—
3001	67 Aquarii	−0·003	−0·02
3008	46 Pegasi *ξ*	+0·014	+0·48
3010	47 Pegasi *λ*	+0·004	+0·01
3012	70 Aquarii	+0·003	−0·03
3023	15 Lacertæ	+0·010	−0·01
3028	Bradley 3028	—	−0·03
3021	74 Aquarii	+0·001	+0·01
3040	81 Aquarii	−0·002	+0·01
3042	82 Aquarii	−0·001	+0·03
3048	83 Aquarii h^1	+0·008	−0·02
3054	Bradley 3054		0·00
3056	55 Pegasi	−0·001	+0·01
3057	56 Pegasi	0·000	+0·03
3059	5 Piscium A	+0·008	−0·13
3062	88 Aquarii c^2	+0·002	−0·05
3065	89 Aquarii c^3	−0·004	+0·01
3105	98 Aquarii b^1	−0·012	+0·10
3113	99 Aquarii b^2	−0·005	+0·06
3125	Bradley 3125	- -	+0·01
3122	70 Pegasi *q*	+0·002	−0·03
3130	101 Aquarii b^4	−0·004	−0·11
3147	Bradley 3147	+0·086	0·00
3145	102 Aquarii ω^1	+0·003	+0·04
3150	103 Aquarii A^1	−0·004	+0·08
3151	104 Aquarii A^2	+0·002	−0·02
3159	106 Aquarii i^1	+0·001	+0·02
3160	78 Pegasi	+0·006	+0·03
3162	19 Piscium	−0·004	+0·02
3166	Bradley 3166	—	+0·01
3167	21 Piscium	−0·001	+0·01
3174	22 Piscium	+0·001	+0·01
3183	26 Piscium	+0·001	+0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
3195	Bradley 3195	—	+0·02
3200	31 Piscium c^1	−0·001	+0·01
3201	32 Piscium c^2	−0·005	+0·03
3212	Bradley 3212	—	+0·18

i Aurigæ. The R.A. of the Fundamenta is 1′ too large.
Bradley 1458. The places given in the Fundamenta are in error.

On the Periodic Time of α Centauri. By E. B. Powell, M.A.

For the last four or five years I have been led to believe that the period of *α Centauri* has been considerably underestimated by calculators of orbits for that binary, myself included; and I now beg to lay before the Society the grounds on which I have come to this conclusion. Dr. Elkin's orbit and Mr. Downing's modification of the same no doubt accord very closely with observations between 1834 and 1877, and I imagine only comparatively slight changes will be found requisite in regard to all the elements save the period. The comes has been watched pretty closely through a change of position angle of more than 330°, corresponding to a change of true anomaly of more than 250°. The question now is, how far the apparent or perspective orbit runs out in the south-preceding direction. In connection with this point I propose to refer to some early notices of the star.

I believe the earliest observation of *α Centauri* is one by Father Richaud, recorded in observations, mathematical and physical, sent by certain Jesuit Fathers to the Royal Academy of Sciences at Paris, and published in 1692. In this work occurs isolated Richaud's note, which is as follows:—

"Regardant à l'occasion de la comète plusieurs fois les pieds du *Centaure* avec une lunette d'environ douze pieds, je remarquai que le pied le plus oriental et le plus brillant étoit une double étoile aussi bien que le pied de la croisade; avec cette différence que dans la croisade, une étoile paroît avec la lunette notablement éloignée de l'autre; au lieu qu'au pied du *Centaure*, les deux étoiles paroissent même avec la lunette presque se toucher; quoique cependant on les distingue aisément."

Richaud observed the comet referred to at Pondicherry in December 1689; hence the epoch of his observation may be taken approximately as 1690. The components of *α Crucis* spoken of are, I imagine, not the two close stars, but those two seen as one and the third—a sixth magnitude star. The close stars are about 5″ apart, while the third is about 90″ distant from the close one. The near stars, if moving, are moving very slowly, though the recorded measures of distance in this century,

supposing they can be relied on, indicate a decrease of that quantity. The use of the word "notablement" supports my view. Now we have Newton's remark in the "System of the World," that in his time the brighter fixed stars appeared through the telescope with a good full light to be 5″ or 6″ in diameter, and that with a fainter light they ran out to a greater breadth. Taking this remark into account it seems probable that the distance of *α Centauri*, as measured in the modern manner from centre to centre of the components, did not in 1690 fall short of 7″, and probably was in excess of that angle. But by forming a table showing the distances, on hypothetical periods ranging through 76, 77, &c., years, as determined by distance measures in the present century, we find that periods of 80, 81, &c., to 86 years are inadmissible in consequence of affording distances below 7″. Thus a period of 80 years would for two revolutions from 1690 bring us to 1850, when the distance was about $6\frac{3}{4}''$; and a period of 81 years in the same way would bring us to 1852, when the distance was $5\frac{1}{2}''$. These considerations seem to bar any period between 80 years and 86 years. It is true, however, that the grounds on which this conclusion is based are not certain ones, and that consequently we cannot do more than attribute a measure of probability to it.

The next notice of *α Centauri* to which I wish to call attention is one carrying much more weight. It is that by Father Louis Feuillée, described as "Religieux Minime, Mathématicien, Botaniste de Sa Majesté, et correspondant de l'Académie Royale des Sciences." The note is in the *Journal of Observations, Physical, Mathematical, and Botanical*, made by order of Louis XIV. between 1707 and 1712. The journal was published in 1714, and the observation was made at Lima on July 4, 1709. The notice is as follows:—

"Sur les deux heures du matin, en attendant que je pusse observer l'émersion du premier satellite de *Jupiter*, que des nuages me cachèrent, j'observai avec une lunette de 18 pieds l'étoile de la première grandeur qui est au pied boréal du devant du *Centaure*; je trouvai cette étoile composée de deux, dont l'une est de la troisième grandeur et l'autre de la quatrième. Celle de la quatrième grandeur est la plus occidentale, et leur distance est égale au diamètre de cette étoile."

There are two points to be noticed in the above extract. First, the comes is declared to have been west of the primary; and secondly, the distance is said to have been equal to the diameter of the comes. We now know that the far larger portion of the orbit of *α Centauri* lies to the west of the meridian through the primary, the eastern portion having been described in the interval between about 1862·7 and 1879·9, or approximately 17 years. It follows, therefore, that if Feuillée's observation be correct, viz. that in 1709·5 the smaller star was west of the larger, the period must either fall short of $\frac{1}{2}(1862{\cdot}7 - 1709{\cdot}5)$, *i.e.* 76·6 years, or must exceed $\frac{1}{2}$ (1879·9—1709·5),

i.e. 85·2 years, any intermediate value being out of the question. It appears highly improbable that an experienced observer such as Feuillée was could have made the mistake of turning east into west; and unless such a mistake was made, the observation must be regarded as of the highest importance. If, as I now believe, so short a period as 76·6 years will not allow of the requisite extension of the orbit of *α Centauri* in the south-preceding direction, it follows that the period must exceed 85·2 years.

Turning to the second point in Feuillée's notice, viz. the apparent distance of the components, and assuming that the distance he referred to was the interval between the apparent disks of the stars, the distance between the components from centre to centre could not well be less than $3''+2\frac{1}{2}''+5''$, *i.e.* $10\frac{1}{2}''$. But forming a table similar to that spoken of when discussing Richaud's observation, we find that such a distance is incompatible with any period between 79 or 80 years and 87 years.

Summing up the results for both Richaud and Feuillée, and even allowing for error in estimating the apparent diameters of the stars, I think the observations of those astronomers, taken with the presumed necessity of allowing a greater extension to the orbit in the south-preceding direction than is compatible with a period of 76·6 years, point strongly to the time of revolution not falling short of 86 or 87 years.

Some three years ago I found that a period of over 89 years, with a semi-major axis of above 18″, and other elements but little different from those already arrived at, afforded results, certainly not in good accordance with observation, but still not offensively discordant save in the case of the epoch 1877·6, when θ_o differed from θ_c by nearly 6°. I do not, however, believe that the period can be so large, and I merely mention the circumstance to show that so great an extension of the time of revolution does not destroy the correspondence of the computed and the observed motions. Last year, after various trials, I arrived at an orbit with a period of 86·56 years, which agreed with observation to within 1° of position angle for all the measures (14 in number) which I put in comparison from 1834 to 1876; from 1876 to 1881 the values of $(\theta_o-\theta_c)$ were larger but not excessive except in the case of the epoch 1878·38, for which the value was 7°·25, the errors for 1880 and 1881 again falling below 1°. Curiously enough the orbit to which I refer made the value of $(\theta_o-\theta_c)$ for 1878 ·185 only $-0°·2$, while Mr. Downing considers θ_o for that date to be very considerably in error. The components were so close to one another in 1877 and the early part of 1878 that errors of some magnitude could scarcely be avoided, especially as the stars are large; and probably it will be advisable to defer making further orbital calculations till three or four years additional measures will, as it were, allow the observations taken in 1877 and 1878, near the lesser minimum distance, to be given only a secondary influence in

determining the elements. I trust the points I have noticed above, some of which I have touched on in an incidental manner in former papers, will be considered to possess some interest; and I observe that in the remarkable papers lately put forward by Drs. Gill and Elkin upon the parallax of *α Centauri* it is stated that those astronomers saw reason to conclude that the period of *α Centauri* must be longer than the value originally assigned by Dr. Elkin.

In arriving at the orbits formerly submitted by me, I placed great reliance upon Maskelyne's observation at St. Helena in July 1761, according to which the distance was then between 15″ and 16″. The measure was made with a divided object glass micrometer fitted to a reflecting telescope by Short. On hearing, through a common friend, that I was anxious to obtain information regarding this observation, the present Astronomer Royal was kind enough to send me a copy of certain entries in Maskelyne's manuscript note-book referring to measures taken with the above micrometer. From the entries I find that, while Maskelyne made the distance for *α Centauri* to be 15″·6 by two measures, he brought out on the same night the distance of the comes of *β Scorpii* as 7″·2 by one measure. In regard to the latter, he states it was much less exact than the distance measure of *α Centauri*, and he remarks that no observation of distance "of this kind" can be taken very precisely. It may be noticed, in passing, that on the same night the micrometer gave 11″ as the diameter of the disk of *Arcturus*. Now it happens that from the *Philosophical Transactions* of the Royal Society, vol. liv., we learn that in August 1761, while at St. Helena, Maskelyne measured with great care, with a 10-ft. sector, the difference of declination of the two stars of *β Scorpii*, and made it by the mean of six nights to be 13″·97. From this it becomes evident that no reliance can be placed upon the distance measures with the object-glass micrometer, as that apparatus actually made the distance little more than one-half the difference of declination, or in other words, made the hypotenuse of a right-angled triangle only a trifle greater than half one of the sides. In these circumstances it seems clear that we must set aside Maskelyne's distance measure of *α Centauri*, although it was taken with greater care than that of *β Scorpii*, the former being the mean of two observations, and the latter only a single measure; the micrometer was in fact so imperfect in its nature as entirely to vitiate the results. And it is to be recollected that Maskelyne's distance measure was one of the chief supports (in my eyes the chief one) of the short period of seventy-six years or thereabouts.

It must be allowed that La Caille's measures of difference of Declination and difference of Right Ascension do not support so long a period as 86 or 87 years; but his apparatus, however carefully and skilfully used, was certainly not competent to deal at all accurately with seconds of space; therefore the results

arrived at by this astronomer cannot be permitted to guide us in the present question.

Fallows had also very inadequate instruments to work with, consequently much weight cannot be attached to his measures; but, so far as they go, they suggest a *very* considerably greater elongation in the south-preceding direction than Dr. Elkin's orbit would allow, in fact a greater one than even now seems to be warranted by the circumstances I have dwelt on above. I may mention that the measures of Rümker and Dunlop also indicate that the orbit runs out tolerably far in the south-preceding direction.

On the whole I cannot but think it highly probable that the apparent orbit is considerably larger than has been supposed, and that the period may embrace some 86 or 87 years.

Hampstead:
1884, *Nov.* 12.

Note on Stellar Photography. By A. A. Common.

Photography, as a means of charting the stars in a rapid and most accurate manner, is now, through the introduction of the gelatine dry plate, likely to come into extensive use, if it does not entirely supersede the old method of eye observation of each separate star. Its power to picture the stars in their proper relative positions and magnitudes in a way that is free from personal error, and under conditions that can be easily and certainly reproduced at any future time, renders the work done in this way so valuable in many investigations, that it is hardly possible to properly estimate it, while the much greater amount of work that can be done will render it still more valuable.

As is well known, photographs of double stars and clusters of stars have been made many years ago, but from the difficulties in connection with the use of the wet plate process then generally employed, the results were not very great in comparison with the trouble that was required. A negative of the *Pleiades*, now in possession of this Society, by Rutherfurd, is perhaps one of the best photographs by this old process.

Many other photographs have been taken from time to time in this manner, but it is but recently that the practicability of taking large fields with comparatively small apertures has been shown.

Attention was, I believe, first drawn to this by the remarkable photographs of the great comet of 1882 that were taken at the Cape and sent home by Dr. Gill. Through the kindness of Dr. Huggins I saw one of these photographs very soon after it came to England, and I must say that I was extremely surprised at the number of stars that were shown. It is true that they were large and ill-defined, particularly at the edge of the plate, but

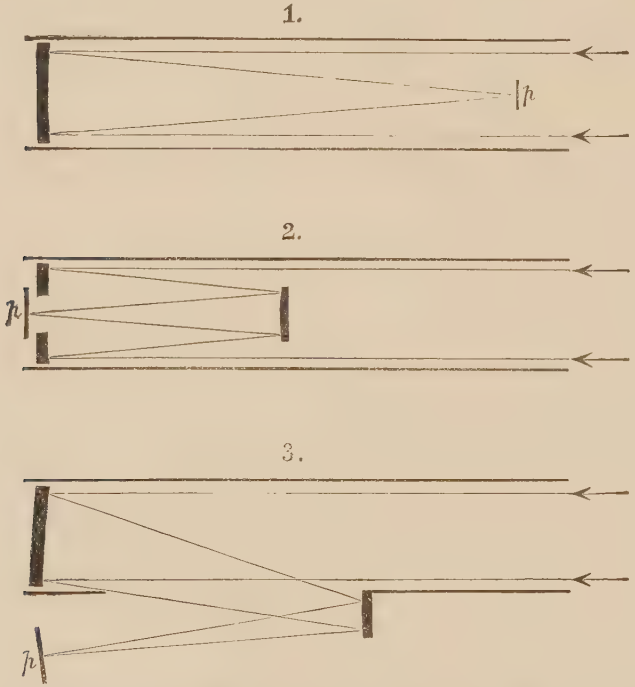
there they were, and that was the great thing, considering that only an ordinary portrait lens had been used.

I had in 1879, in the course of experiments with the 3-foot telescope, taken pictures of the *Pleiades* with $1\frac{1}{2}$ minutes' exposure, using the gelatine dry plates then being introduced, that showed stars of the 8th and 9th magnitude.

These comet photographs, however, opened out a new way that I was not slow to follow. I was then (in 1882) working at the photographs of the nebula in *Orion*, devoting every fine night to that purpose. One evening when thus working I attached a small camera to the mounting of the large telescope, and with a lens of about $\frac{3}{8}$-inch aperture I exposed a plate for twenty minutes—the time I was then giving to the plate in the large telescope. The result of this first experiment with small aperture was most surprising. The stars that form the figure of *Orion* were there, and stars in the centre of the field to about the 9th magnitude, and a portion of the nebula itself. The stars near the edge were a little oval, but not very objectionably so. I did nothing further just then, but determined to follow the matter up by more experiments. For this purpose I completed a 6-inch refractor by February 1883, with a mounting specially made to carry cameras on the declination axis; and through the kindness of Messrs. Ross, the opticians, I tried almost every kind of lens that is made for photography. Judging by the picture already mentioned, I had contemplated as possible a field of at least 10° without altering the perfectly round shape of the stars, or losing too much light at the edge of the field; but the results of many experiments with symmetrical, rapid symmetrical, landscape, portrait, and other lenses was not favourable. Some gave better fields than others, but the amount of astigmatism and loss of light away from the centre was greater than with the first small lens. I came to the conclusion that with the best ordinary lens it would not be safe to rely on more than 4° or 5° of the centre of the field for freedom from astigmatism and equality of illumination. Messrs. Ross told me they could make a special lens that would be very much better, but I have not yet learnt that anything has been done by them.

I have brought here to-night a picture of part of *Orion* taken during these experiments; it is cut out of the centre of a larger plate, but it shows what can be done with such lenses as those I have named. A comparison with Argelander's Atlas shows that some of his 9th and 10th mag. stars are shown, and that in several cases there is considerable difference in positions and magnitudes. I have also brought a picture of the *Pleiades* taken with a lens of 4-inch aperture and about 2-feet focus, and one of the plates taken with the very small lens. In using photography, the first thing would naturally be work in some plan that would allow a series of pictures to be taken of the whole heavens on as large a scale as it could be done on in a reasonable time; for this purpose the lens appears the most suitable, leaving the reflector

for large pictures of objects of interest, such as nebulæ, clusters, &c. The difficulty with the lens has, however, led me to consider how the reflector might be utilised; the ordinary arrangement does not lend itself to large fields, but from various experiments I have reason to think that it *is* possible to use the reflector for this purpose. The choice seems to me to be practically between three different arrangements: the first is when the sensitive plate is placed in the principal focus, directly in front of the large mirror; the second is a modification of the Cassegrain telescope (amounting almost to a new form) made by increasing the size of the small mirror to one half or even more



of the diameter of the large mirror; the third is a form of telescope invented in Germany, and not much known here—it is called, I believe, the "Brachy" telescope, and is on the same plan as the Cassegrain, but the small mirror is placed outside of the tube, so to speak, and the mirrors are used obliquely. For the purpose of making the different arrangements more easily understood, I have given an outline sketch of each that will show at once the distinctive differences between them. The first arrangement has simplicity to recommend it, and as a large telescope I can imagine nothing better. There is only one surface, so that the greatest possible amount of light is used effec-

tively, and it is symmetrical; for this work, however, where flatness of field is necessary, I do not think it can be so good as either of the other forms. The second arrangement is peculiar, and with a mirror of 5-foot aperture the supports of such a second mirror might be difficult; on the other hand, the loss of reflecting surface can be made up by a trifling increase of diameter in comparison with other forms. The connection between the mirrors can be made very rigid as they are so near, the surfaces can be wrought to suit each other and to give a flat field in addition, all is symmetrical, and that is important, and the plate is in a convenient place for exposure under examination, and is quite protected by the smaller mirror from the direct light of the sky.

The largest instrument of this kind that I have tried has a concave mirror of $9\frac{1}{2}$ inches, and a smaller mirror of $4\frac{1}{2}$ inches diameter; the focal length of large mirror is 43 inches. This instrument, roughly mounted in a wooden box, and attached to the 6-inch telescope, forms a photographic telescope that will give a picture of an 11 mag. star in thirty minutes under very unfavourable circumstances. The field of view is 3° only, as the hole that I cut in the large concave is not larger, but as far as it goes it is good. Altogether the arrangement has been more satisfactory than I expected, and I intend to try larger sizes to see if any new features become developed.

The third arrangement I have not tried with photography, but it is quite possible that it may be the best for this purpose. I have tried it on artificial stars, and the way in which the second mirror corrects the astigmatism due to the oblique position of the large one is most remarkable. I cannot find very much information about it, though, no doubt, some exists. I mention it and the other form in the hope that some one may make some trials of it for photography, as it is important to have all the information possible as to the best kind of telescope for this purpose, and this can be best done by many independent experiments. It appears to me that the aim ought to be the production of photographic charts made up of separate fields of 4°, 5°, or 6°, or even more if it be possible, on a scale at least twice that of Argelander's Atlas, and including stars of the 12th magnitude, and this with a moderate exposure.

I believe this, and more than this, to be now possible, but it is necessary that the best way to do it should be clearly shown.

Note on a Method of giving Long Exposures in Astronomical Photography. By A. A. Common.

In exposing a sensitive plate for a long time the image is liable to shift, from the driving clock not keeping pace with the diurnal motion, from change in the apparent place of the object due to refraction, from change in the position of the focal plane

due to alterations of temperature, and in the case of reflectors from changes of position of the mirrors due to different strains coming into play as the telescope moves round. None of these movements are very large or come into play quickly, but if allowed to act without immediate correction they will spoil the picture.

In the case of small instruments it is only necessary to watch the object in the finder, and use the fine movements of the telescope as required; but in large heavy instruments, and particularly in the case of reflectors, this cannot be done, the connection between the finder and the mirrors being at all times bad. When using a large reflector for long exposures, as in taking the nebula photographs, I used an apparatus that I devised for watching and correcting any errors of movement in the telescope, which is so simple and efficient, that a description may be useful to those who contemplate work similar to that for which I used it. In this case the image of a star as near as may be to the object to be photographed, formed by the same mirror as produces the picture, was observed, and by means of cross-wires attached to the same slide that held the plate, and moving with it, the cross-wires and the plate were kept constantly in one position with regard to this star, and consequently to the image falling on the plate.

The general arrangement may be thus described. On the tube that fits the eyepiece end a plate is fixed, carrying two slides capable of movement by means of fine screws in directions at right angles, in the manner of the ordinary slipping piece in use with a micrometer. The upper slide is for carrying the plate holder, and has two screws to hold it in position. A box is fixed to this slide to carry the cross-wires and eyepiece; in the box there are three grooves—the lower one carrying the cross-wires, the next a plate of glass to protect them from the breath of the observer, and the other to carry the eyepiece. The cross-wires and the eyepiece can be placed at any point in the length of the box so as to be more easily placed on a suitable star. A lamp is attached to the end of this box to illuminate the cross-wires in the usual manner. If through any cause it is necessary to interrupt the exposure, it is only necessary to close the shutter of the plate-holder, and then before opening it again to see that the cross-wires are exactly on the image of the star. I have often had to so interrupt a long exposure, but I have never found that the apparatus failed to act perfectly.

I do not think that long exposures can be made, especially with reflectors, without some such arrangement as this to prevent injurious shift of the image; and the larger the telescope the more important it would become, as the movements due to the strains in the mounting would be greater. It becomes, therefore, interesting to consider how this could be done in the case of a large reflector when it is determined to place the plate in the centre of the tube (using this word in its proper sense as

applied to reflectors) at the principal focus of the great mirror, and work the correcting apparatus from below, entirely dispensing with any platform or tower for the observer. This arrangement would be the most simple and probably the best that could be used; there would be but one reflecting surface, and everything would be symmetrical. To work the apparatus for correcting during exposure by keeping the cross-wires rigidly on the star, to open and close the shutter, and, above all, to exactly focus the plate, seems at first a difficult thing to do by an observer placed, it may be, fifty or sixty feet away; but by means of small electro-motors these things can be easily done. There is of course behind the plate a good deal of space available for the mechanical arrangements, and the details would not offer any difficulty to any one to work out; and as the power would be conducted by thin wires, much less obstruction would be offered by these than by any other merely mechanical arrangement; in fact, the wires that support the apparatus would do for the conductors. With the optical arrangement that would be necessary there would not be any particular difficulty.

The two things that are required are, that the focussing be accurately done, and that the image of the cross-wires and the star should be as plainly seen by the observer on the ground, as if he were observing them with an eyepiece directly. If the power is sufficient, the same apparatus that is used to observe the star and wires will do to focus the plate by simply focussing the star accurately, and then moving the wires previously adjusted to the same plane as the sensitive plate, until they are also in focus.

There are several ways in which this could be done. The simplest would be to fix two right-angled prisms, one on the apparatus behind the cross-wires, where the eyepiece is in the aforesaid arrangement, and one outside the tube in a similar place to the eyepiece in a Newtonian reflector, so that an object-glass of 4 or 6-in. aperture placed at its focal distance from the image of the cross-wires would send the collected rays on, parallel to another object glass near the lower end of tube, that would bring them to a focus in a convenient place for observation. There are of course other optical arrangements that would do, but this would, I think, be found to answer well.

Ealing: 1884, *Nov.*

A Remarkable Configuration of Stars in the Milky Way detected by Photography. By Rev. T. E. Espin, B.A.

In October last year some experiments were undertaken by me with a view to photographing large fields of stars, and reducing the photographic magnitudes from the plates. By the courtesy of Professor E. C. Pickering I was allowed to see the negatives that he had with him during his visit to Europe. Early in

October 1883 a camera with a lens of $2\frac{1}{2}$-in. aperture was mounted on an equatorial stand at West Kirby, and several negatives were obtained. Two were exhibited at the November meeting of the Liverpool Astronomical Society, and the council determined to solicit subscriptions for erecting a large equatorial stellar camera. In the mean time Mr. Howard Grubb, taking a kindly interest in the work, generously placed at my disposal a powerful instrument at a nominal cost. This instrument was erected in March at West Kirby. It is an equatorial stellar camera with a compound lens of $4\frac{1}{2}$-in. aperture, and 15·8 in. focal length. The equatorial is driven by clockwork.

The line of research which I proposed to undertake was two-fold: (1) The determination of the star magnitudes from the photographs; and (2) the solution of the problem of charting parts of the heavens by photography. The preliminary results of the first part of the research were published last May as *Transactions* No. 3 of the Liverpool Astronomical Society. The second part is more difficult, and till a few weeks ago nothing satisfactory had been accomplished. Some excellent negatives had been obtained, but all attempts at printing from them were failures. The fainter stars in the negatives were not reproduced on the prints. Slow printing and rapid printing were alike useless in this respect, and I had given it up in despair, when the discovery of the remarkable "horseshoe" configuration in *Cygnus* again led me to desire greatly to print from the negatives.

It suddenly struck me that it might be possible to enlarge the images and photograph them; and that then negatives might be obtained which it would be possible to print from. After one or two attempts I was successful, and in printing from the enlargements I found that the faintest detail in the original negative was readily reproduced on the print.

The print that I have the honour to present to the Society* was obtained from an enlargement of a negative taken with the camera on Sept. 20 with one hour's exposure. The plate used was one of Wrattan and Wainwright's "drop-shutter" plates, which I have found to be the most rapid of any obtainable.

The night was remarkably clear, and the exposure from half an hour before to half an hour after meridian passage.

The remarkable configuration of stars photographed on the plate includes five of Argelander's stars.

The number and places of these are as follows, as taken from Argelander:—

D.M. +46°3188	XXI.	2 13·6	+46 39·5	9·2
D.M. +46·3191		2 21·2	41·5	7·7
D.M. +46·3192		2 34·7	43·4	8·7
D.M. +46·3198		3 27·1	40·2	7·7
D.M. +46·3201		3 54·2	40·7	7·1

* The print may be seen in the Society's library.—Ed.

The remaining eleven stars are not in Argelander.

The smallest star photographed is probably not much above the 11th mag. Looking at the field with a 5-inch refractor, many of the stars seemed minute. On the focussing glass of the camera the Milky Way appeared as a bright glow, and this is plainly visible as a bright nebulosity on the print.

A Photometric Comparison of the Light transmitted by certain Refracting and Reflecting Telescopes of Equal Aperture. By Prof. C. Pritchard, D.D., F.R.S.

In a communication to the Society respecting the Oxford observations of stars occulted by the Moon during its recent total eclipse, I had occasion to mention the occultations of four faint stars, three of them approaching the twelfth magnitude, and not included in Dr. Döllen's list, and not found in any catalogue with which I am acquainted. Of these four stars one only was distinctly seen in the De la Rue Reflector of 13-in. aperture, although the other three were sufficiently salient to admit of observation during the eclipse by the Grubb Refractor of $12\frac{1}{4}$-in. aperture, and of their subsequent identification by means of that instrument.

This circumstance directed my thoughts once more to the long-agitated question concerning the relative light capacities of reflecting and refracting telescopes of approximately equal aperture. There being "nothing new under the Sun," I half expected to find that the question had long since been finally settled, and that there was no need of further research. On inquiring in those quarters where I thought the information, if it existed, would be possessed, and on referring so far as I could to written authorities, I came to the conclusion that the comparisons in question had up to the present time been conducted on insecure bases, and in fact were simply conjectural. Dr. Robinson, the late distinguished astronomer of Armagh, and who, I believe, would be admitted to be among the most reliable authorities on the question, thus writes in the *Monthly Notices* for May 1876:—"William Struve thought that the Dorpat Telescope of 9·6-in. aperture might be compared to Herschel's 20-ft. Reflector of 18-in. aperture;" and he adds, "We are told that M. D'Arrest's Achromatic of 11-in. aperture is very superior to Herschel's 20-ft. Telescope, and almost equal to the great telescope of Lord Rosse." Again, in the *Philosophical Transactions* for 1869 we find the same high authority, in his memoir on the great Melbourne Telescope, writes as follows:—"If we seek any comparison of the light of the two kinds of telescopes, based on actual measures, little is to be found but vague conjectures; thus M. Otto Struve *thinks* that Mr. Lassell's Telescope of 2-ft. aperture is nearly equal to the light of the Pulkowa 16-in." Dr. Robinson, in the *Monthly Notices* already cited, goes on to express

a hope that as the Paris Observatory would soon be in possession of two magnificent instruments of both kinds, the question of their relative light capacity would soon be set at rest. I am not aware that this hope has been practically realised. Moreover, I believe that a committee was appointed by the British Association for the prosecution of a kindred inquiry, but I cannot find that a report has been actually published on the subject.

In the middle of these wide, not to say somewhat wild, conjectures, it occurred to me that the Observatory under my direction at Oxford is in possession of a photometer especially adapted to the determination of the question at issue; and, thanks to the generosity of Dr. De la Rue, possesses also two mirrors—the one of metal, which has done such excellent work in the hands of its donor, and also a silver-on-glass speculum (by With) of the same dimensions and of nearly equal excellence. With these means before me I determined to make the necessary measures, with a strong expectation of success.

Accordingly, immediately after the eclipse referred to, I requested my two able assistants, Mr. Plummer and Mr. Jenkins, whose experience now extends over many thousand photometric measures, to prepare a convenient list of stars, varying in magnitude from the second to the sixth, and, by means of them, measure their relative light-intensities as transmitted by the three instruments, viz. the Grubb Refractor of $12\frac{1}{4}$-in., and the two mirrors of about the same aperture, and already described.

The process which I arranged was as follows:—

Each of the two observers, armed with his own wedge photometer with its eyepiece attached, observed on it the point of extinction of each of the selected stars in each of the three instruments. Five extinctions were observed in the case of each star, and the resulting mean was adopted. From these data the relative light capacities of the three instruments were computed, on the principles and after the manner indicated in my memoir in the 47th volume of our Society's *Transactions*.

The observations made by Mr. Plummer and Mr. Jenkins possess the same degree of close accordance which has hitherto characterised their photometric work, and leave no doubt on my mind as to the accuracy of their conclusions.

The results are as follows:—

Light transmitted by the Grubb Refractor, $12\frac{1}{4}$-in. aperture	:	Light transmitted by the De la Rue Reflector 13-in. aperture	::	1·89 : 1
Light transmitted by the Grubb Refractor, $12\frac{1}{4}$-in. aperture	:	Light transmitted by the silver-on-glass mirror 13-in. aperture	::	1·5 : 1

The average deviation of the individual measure from the adopted mean does not exceed the light indicated by about $\frac{1}{20}$th of a "magnitude" on Pogson's scale.

It ought here to be remarked that the De la Rue metallic

mirror has now been in constant use for upwards of thirty years, though still in a very serviceable condition. The silver-on-glass speculum, by With, is in a high state of polish; moreover, it has long been known that the reflective power of silver exceeds that of speculum metal, and this also no doubt is the case (though possibly not to an equal extent) with chemically deposited silver on glass.

Further, it will be observed that I have not here entered upon the general question of comparing achromatic object glasses with mirrors, whether of speculum metal or of deposited silver; I have confined the question to the large telescopes with which I am necessarily familiar, though I have little doubt they may be regarded as representative instruments. It is probable that no two object glasses, and no two mirrors, will be strictly alike in respect of light capacity, though possessing a general family likeness.

Nor have I here attempted to obtain the ratio of the amount of the light incident on the mirror or the object glass to that which is reflected from, or refracted through it, simply as a mirror or an object glass; therefore I do not touch on the question of the relative photographic values of the two kinds of instruments; but I repeat that I have confined my investigation to the relative amounts of light passing through the eye-lenses of the respective instruments. I am here treating of three telescopes and not of photographic cameras; still less am I here pretending to decide as to the relative superiority of the two forms of telescope. There are, however, two important remarks made by the late Dr. Robinson in the *Monthly Notices* to which I am disposed to give my entire assent. The one is, that in proportion as the apertures of the two sorts of instruments are greatly increased, the superiority of the light-transmitting power of the Refractor becomes less and less over that of the Reflector. Few persons are probably aware of the considerable loss of light in its passage through an object glass, on account of surface reflections and absorption of light by the materials. The latter loss of light increases, after a geometrical ratio, with the thickness of the glass; and this augmentation of thickness also necessarily increases at a rapid rate with any increase of aperture. From this peculiar idiosyncrasy reflectors are free; and no doubt if it were possible to sufficiently increase the aperture of an object glass, there must at length arise a thickness of glass material which will absorb more light than is lost by reflection from the speculum. This limit, however, is probably practically unattainable by any otherwise good object glass capable of being manufactured and figured; whereas the possible limits to the aperture of a reflector are at present not only not attained, but even as yet unsuspected. I agree consequently with the eminent philosopher of Armagh in the opinion that attention may in future be most profitably directed to the increase of the aperture of mirrors whether parabolic or plane, for the extension of our knowledge in astronomical physics.

The following Tables contain the particulars of the individual measures on which the results referred to in the foregoing statements are founded.

TABLE I.

Comparison of the Light transmitted by the Grubb Refractor of 12¼-in. aperture and the De la Rue Reflector of 13-in. aperture.

Star selected.	Tabular mag. of Star selected.	Diff. of Light expressed in mag. — Wedge A.	Ratio of the Lights transmitted.	Diff. of Light expressed in mag. — Wedge B.	Ratio of the Lights transmitted.
β Andromedæ ...	2·2	0·76	2·01 : 1	0·68	1·87 : 1
g Pegasi ...	2·5	0·61	1·76 : 1	0·70	1·91 : 1
θ Andromedæ ...	4·5	0·75	2·00 : 1	0·83	2·15 : 1
32 Andromedæ ...	5·5	0·63	1·79 : 1	0·70	1·91 : 1
75 Piscium ...	6·2	0·67	1·85 : 1	0·68	1·87 : 1
Mean ...		0·684	1·88 : 1	0·718	1·94 : 1
		Av. dev. $0^m·06$		Av. dev. $0^m·05$	

TABLE II.

Comparison of the Light transmitted by the Grubb Refractor of 12¼-in. aperture and the De la Rue Telescope with the Silver-on-Glass Mirror (With), also 13-in. aperture.

α Aquarii ...	3·0	0·47	1·54 : 1	0·49	1·57 : 1
π Pegasi ...	4·1	0·40	1·45 : 1	0·42	1·47 : 1
59 Pegasi ...	5·3	0·49	1·57 : 1	0·56	1·67 : 1
Mean ...		0·453	1·518	0·49	1·57 : 1
		Av. dev. $0^m·04$		Av. dev. $0^m·05$	

From hence it appears that the light transmitted by the Refractor of 12¼-in. aperture : that transmitted by the De la Rue Telescope with a 13-in. metallic speculum :: 191 : 100; and in the case of the 13-in. silver-on-glass mirror (by With) 155 : 100.

I will now only quote a concluding remark made by Dr. Robinson in the *Monthly Notices* already cited, to the effect that comparisons such as are here instituted can only be effectually made where the two forms of instruments are set, as it were, side by side: "The comparison can only be fairly made (he truly says) when the conditions are identical; when the locality, the night, the object, the observers are the same; and, I may add, when there is no personal or party bias in the judge." I trust these conditions are well secured in the research detailed in the present communication.

Postscript.—On the reading of the above paper to the Society, a long and interesting discussion took place, in the course of which it became evident that some misapprehension existed as to

the nature and use of the photometer employed. In order, therefore, to remove any doubts as to the exact meaning and scientific character of the measures recorded in the paper, I may observe that the bases of the cones of light proceeding from the stars on to the eye-lenses of the photometers as measured by a dynamometer, in the case of the Grubb instrument, are fairly represented by one-thirtieth of an inch, and in the case of the Reflector (with either mirror) by one-twentieth of an inch: between them and the eye, close to these small luminous circles, the photometer wedges traverse; and furthermore, close to the wedge is placed the eye of the observer, guided and restricted in direction by a small diaphragm with about one-tenth of an inch circular opening. It is certain, therefore, that the whole of the light incident on the object-glass or mirror passes through the wedge and through the pupil to the retina.

I cannot, myself, conceive a more perfect or simple form of a photometer; and, as to the skill with which it is handled, the observations in the text, printed from the note-books of the two able observers, speak to the initiated for themselves.

Since writing the above, I have measured photometrically the ratio of the incidents to the transmitted light of the Grubb 13-in. object glass, and I find the result in very good accordance with that obtained by Dr. Robinson in 1869 for the same object glass by a totally different form of photometer. This and a few similar investigations I propose to make the subject of my next communication to the Society.

Note on a Comparison of the Photometric Magnitudes of the same Stars Observed at Harvard College and at the University Observatory, Oxford. By Prof. C. Pritchard, D.D., F.R.S.

The total number of stars of which the magnitudes have been photometrically measured, both at Harvard College and at Oxford, is up to the present time 1,801.

Of these the number of accordances within one quarter of a magnitude is 1,569: within the tenth of a magnitude the number of accordances is 717.

The number of discordances amounting to a quarter of a magnitude, and less than four-tenths, is 168 out of the 1,800.

The number of discordances amounting to four-tenths of a magnitude and beyond is 64.

Among the probable or possible causes of these discordances, comparatively inconsiderable as they are, may be reckoned:—

1. Errors of observation at one or both Observatories, as shown by the considerable residuals recorded in the Harvard memoir, and by the variable but smaller "average deviations" printed in the Oxford work.
2. The general application of the mean value of the atmospheric absorption on individual nights, whereas this

absorption varies very greatly, and even unexpectedly, with the meteorological conditions of the time and place of the observations.

3. The occasional observations on nights not favourable to accurate measurement.
4. The variability of the lustre of the stars themselves.

It does not appear that either photometer, in its use or construction, is open to systematic error; and further, the effect of small differences of colour does not seem to affect the photometric determination. But there is observable a tendency in the Harvard observations to represent the zenithal magnitudes of stars, at a considerable distance from the zenith, as slightly brighter than the results derived at Oxford. This difference would, to some extent, be explained by supposing the co-efficient of atmospheric absorption, as used at Harvard, to be in excess of its actual amount. The coefficient 0·25 mag. is slightly larger than has been found at Continental observatories, but it is not here suggested that the Harvard value rests on a less secure basis than the others.

Oxford University Observatory:
1884, *Nov.* 13.

Observations of Stars Occulted by the Moon during the Eclipse of October 4, 1884, *at the University Observatory, Oxford.* Made under the direction of Prof. C. Pritchard, D.D., F.R.S.

	Immersion.		Emersion.	
Phase				
Instrument	Grubb Refractor.	De LaRue Reflector.	Grubb Refractor.	De LaRue Reflector.
Aperture	12¾ in.	13 in.	12¾ in.	13 in.
Power	120.	150.	120.	150.
Observer	Plummer.	Jenkins.	Plummer.	Jenkins.
G.M.T.	h m s	h m s	h m s	h m s
63*			9 31 14·5	9 31 14·3
69			9 39 30·1	9 39 29·8
71			9 19 32·8	
74			9 50 9·0	9 50 8·3
76			9 32 19·0	9 32 19·1
81	9 32 22·7	9 32 23·2	10 36 59	
82	9 23 51·4		10 14 31·7	10 14 33·1†
85	9 23 55·1	9 23 52·3	10 30 52·2	10 30 50·8
94	10 6 34·7	10 6 33·8		
95	10 11 42·1	10 11 43·0		
96		10 39 26·6		
106	10 37 11·0	10 37 12·9		
107		10 37 26·8		
108 }	10 36 6·4	10 36 6·4‡		
109 }				

* Numbers as given in Dr. Döllen's list, *Ast. Nach.* No. 2615.
† Star faint. ‡ The immersion of the two stars was simultaneous.

Stars observed as Occulted, but not given in Dr. Döllen's List.

				Estimated Position Angle.
(1)	9 34 1·4			86°
(2)			9 37 59·2	160
(3)		9 33 24·2		80
(4)			10 13 47·8	315

Approximate coordinates of the Four Occulted Stars not given in Dr. Dollen's List.

R.A. of (1) = R.A. of 85+4′ 14″	Decl. of (1) = Decl. of 85+2′ 5″
„ (2) = „ 76+3 47	„ (2) = „ 76+0 39
„ (3) = „ 85+4 31	„ (3) = „ 85+3 37
„ (4) = „ 81−7 27	„ (4) = „ 81+5 9

Owing to the peculiar condition of the occulting limb in respect of illumination, the observations of Immersion were practically more difficult than those of Emersion. The observations of Emersion of stars not predicted may possibly have been affected by unexpectedness of the phenomenon and the greater faintness of the stars.

Altogether 22 phenomena were observed, including the occultation of the four faint stars not predicted in Dr. Döllen's list.

University Observatory, Oxford:
1884, *Nov.* 13.

Total Eclipse of the Moon, 1884, *October* 4. *Observed at the Radcliffe Observatory, Oxford.*

(*Communicated by E. J. Stone, M.A., F.R.S.*)

This eclipse was observed at the Radcliffe Observatory, Oxford, with the only two instruments available for the purpose, the Heliometer of 7·5-inches aperture, and the 7-inch Equatorial. Both semi-lenses of the Heliometer were used, but the images were practically coincident. The faint stars occulted before totality were looked for, but none could be observed until the No. 63 of Struve's list. The observations with the Heliometer were made by Mr. Wickham, those with the Equatorial by Mr. Robinson. As there were only two instruments available, I merely watched the eclipse with the naked eye. The eclipse was much the darkest that I have ever seen, and just before the instant of totality it appeared as if the Moon's surface would be invisible to the naked eye during totality; but such was not the case; for with the last appearance of the bright reflected sunlight there appeared a dim circle of light around the Moon's disk, and the whole surface became faintly visible, and continued so until the end of totality.

Occultations of Stars during the Total Eclipse of the Moon of October 4, 1884.

No in Struve's List.	Name of Object.	Phenomenon.	Instrument.	Time Noted.	Time by Sidereal Standard.	Local Sidereal Time.	Greenwich Mean Time of Observation.	Observer.	Ref. to Notes
				h m s	h m s	h m s	h m s		
63	Arg. Z. +4° No. 126	Disappearance	Heliometer	21 54 33·3	21 54 11·90	21 53 33·67	9 2 48·13	W.	
63	,,	,,	10-foot telescope	21 54 29	21 54 11·50	21 53 33·27	9 2 47·73	R.	(*a*)
71	* 10 Mag.	Disappearance	Heliometer	22 3 25	22 3 3·59	22 2 25·36	9 11 38 37	W.	
85	* 10 Mag.	Disappearance	Heliometer	22 15 38·2	22 15 16 78	22 14 38·55	9 23 49·56	W.	
82	* 10 Mag.	Disappearance	Heliometer	22 16 1·2	22 15 39·78	22 15 1·55	9 24 12·50	W.	
81	Arg. Z. +4° No. 129	Disappearance	Heliometer	22 25 12·0	22 24 50 57	22 24 12·34	9 33 21·78	W.	(*b*)
81	,,	,,	10-foot telescope	22 25 7·95	22 24 50·42	22 24 12·19	9 33 21·63	R.	(*c*)
69	Arg. Z. +3° No. 111	Reappearance	Heliometer	22 31 20·5	22 30 59·06	22 30 20 83	9 39 29·26	W.	
69	,,	,,	10-foot telescope	22 31 18	22 31 0 46	22 30 22·23	9 39 30·66	R.	(*d*)
74	Arg. Z. +3° No. 112	Reappearance	Heliometer	22 42 1·3	22 41 39·85	22 41 1·61	9 50 8·30	W.	
74	,,	,,	10-foot telescope	22 41 56·3	22 41 38·75	22 41 0·51	9 50 7·20	R.	(*e*)
94	* 9–10 Mag.	Disappearance	Heliometer	22 58 30	22 58 8·54	22 57 30·30	10 6 34·29	W.	(*f*)
94	,,	,,	10-foot telescope	22 58 24·5	22 58 6·94	22 57 28·70	10 6 32·69	R.	(*g*)
95	Arg. Z. +4° No. 131	Disappearance	Heliometer	23 3 39·2	23 3 17·74	23 2 39·50	10 11 42·64	W.	
95	,,	,,	10-foot telescope	23 3 35·7	23 3 18·14	23 2 39·90	10 11 43·04	R.	(*h*)
82	* 10 Mag.	Reappearance	Heliometer	23 6 28·0	23 6 6·53	23 5 28·29	10 14 30·97	W.	(*i*)
82	,,	,,	10-foot telescope	23 6 24·0	23 6 6·43	23 5 28 19	10 14 30·87	R.	(*j*)
85	* 10 Mag.	Reappearance	Heliometer	23 22 49·5	23 22 28·02	23 21 49·78	10 30 49·78	W.	(*k*)
109	Arg. Z. +4° No. 133	Disappearance	Heliometer	23 28 24·2	23 28 2·71	23 27 24·47	10 36 23·56	W.	
109	,,	,,	10-foot telescope	23 28 20·0	23 28 2·41	23 27 24·17	10 36 23·26	R.	(*l*)
107	* 9–10 Mag.	Disappearance	Heliometer	23 29 42·2	23 29 20·71	23 28 42·47	10 37 41·35	W.	(*m*)

Notes.

(*a*) Fair observation, but could not secure exact tenth of second. (*b*) Seemed somewhat brighter than 9·5. (*c*) Instantaneous; observation very good. (*d*) May be a second late; was not looking at the exact point of reappearance. (*e*) Instantaneous. Counting $\frac{1}{2}$ sec. fast after occultation (reappearance), but observer picked up correct second before observation. (*f*) "Gradual" disappearance. (*g*) Very fair observation. (*h*) Seemed to enter limb 2^s or 3^s and then vanished suddenly; time noted satisfactory. (*i*) Good. (*j*) Good; instantaneous. (*k*) Not quite certain; star very faint. (*l*) Good; instantaneous. A faint companion (Struve's List, No. 108) disappeared just before this time. (*m*) Faint.

Power used:—Heliometer 80: 10-foot telescope 109. For Struve's List see *Astronomische Nachrichten*, Band 109. No. 2615.

In converting Oxford Mean Solar Times into Greenwich Mean Solar Times the following Longitude has been used: $5^m\ 2^s{\cdot}60$ W.

Occultations of Stars observed at Dun Echt during the Total Lunar Eclipse of October 4, 1884.

(*Communicated by Lord Crawford.*)

1. Observations with the Grubb Equatorial of 15·06-ins. aperture, power 122; observer, Ralph Copeland.

No. in the Pulkowa List.	Magnitude.	Phenomenon.	Observed Time by Chronometer.	Dun Echt Mean Time.
			h m s	h m s
94	9–10	Disappearance	10 16 24·5	10 6 41·8
			by Chronograph	
95	9·5	Disappearance	23 5 46·8	10 10 45·3
82	10	Reappearance*	23 9 50·7	10 14 48·5
85	10	,,	23 22 9·5	10 27 5·3
81	9·5	,,	23 22 59·7	10 27 55·4
109	8·8	Disappearance	23 25 56 4	10 30 51·6
108	9–10	,, †	23 25 57·2 − 0s·5	10 30 51·9
107	10	,, ‡	23 28 23·4	10 33 18·2

	m	s	s
The chronometer corr. at 7h·9760 by chronom.	= −9	41·73	−0·4158 per hr.
The chronograph corr. at 22h 35m·3 by chronog.	= +	59·34	+0·0822 ,,

State of Weather and General Remarks.

Although there were only a few cumulus clouds scattered over the heavens, and the sky in general was fairly clear, the illuminated haze around the Moon was too bright to permit of stars 57, 62, 69, and 71 of the Pulkowa list being seen at all, even in the 15-in. telescope. No. 74, of the 9·3 magnitude, was, in fact, the first star made out, and that only with extreme difficulty, shortly before its disappearance, which took place

Notes.

* 82 reappeared suddenly.

† (108) Signal given half a second too late; the disappearance followed so closely on that of 109, that the key could not be pressed early enough for the second record.

‡ (107) The Moon's limb was of a bright primrose colour, and the star appeared to cling to the edge for several seconds before disappearing.

By the time (10h 16m·6 G.M.T) when 94 ought to have reappeared, the sky had become quite white through illumination by the uneclipsed part of the Moon, and the limb was not visible for more than 3′, or at most 4′ from the northern cusp. The 9m star, 106*a*, the place of which is given below, was seen at 11h 21m G.M.T., about two minutes after egress, and its reappearance might have been observed if attention could have been directed to the *exact* place of emergence. On the other hand, the 8m·8 star 109, which was predicted to reappear at 11h 49m 50s G.M.T., although caught sight of about 30s later, was then so very faint that its egress could not have been observed with more certainty than that of a comparatively small star at the Moon's bright limb under ordinary conditions. Its 9–10 mag. companion, 108, was indistinguishable in the glare, and within about another minute the star itself had disappeared in the increasing light of the emerging Moon.

about $9^h\ 3^m\ 52^s$ G.M.T., or 15^s later than predicted; but the observation is altogether too uncertain to be of any use beyond showing that the star was actually seen. After this for a time the clouds were very troublesome, the only record being to the effect that a momentary glimpse of the Moon's eclipsed limb was obtained at $9^h\ 17^m$. About 10^h G.M.T. a sudden change for the better took place, and at $10^h\ 1^m\ 45^s$ the group of stars 69, 71, 74, 76, and 76*a*,* the last certainly not brighter than the 11th magnitude, and not in the Pulkowa list, were beautifully seen in a splendid black sky through a momentary rift in the clouds, the star 74 which had just emerged being only some 30″ from the Moon's limb. Unfortunately there were no occultations for the next quarter of an hour, but those that came subsequently were observed with great certainty until about $10^h\ 43^m$ G.M.T., when the rapid brightening of the Moon as it approached the margin of the shadow began again to cast difficulties in the way. By 10 or 12 minutes after the end of the total phase, or by 11^h G.M.T., the special facilities of the occasion may be said, in a great measure, to have passed away, although from what was seen of stars 106*a* and 109 it seems that the egresses of 8 or $8\frac{1}{2}$ magnitude stars might have been observed at the Moon's obscured limb until the end of the actual *umbral* eclipse, and conversely the disappearances of such stars might have been perceptible at the commencement of that phase. The record at $10^h\ 2^m$ shows that near the middle of a total lunar eclipse stars of the 11th magnitude may be advantageously placed on an occultation list.

When the Moon was visible the corresponding places of the stars on her limb were readily found by simply setting the telescope in declination, which can be quickly done from the eye-end of the instrument. At other times use had to be made of the configurations of neighbouring stars, as shown in the map.

2. Observations made with the 6·06-in. Simms' Equatorial, power 91, by Mr. J. G. Lohse.

As a preparation the 16 stars for which the predicted times of disappearance and reappearance had been sent from Pulkowa by M. Struve were mapped on a large scale on millimetre paper, together with the apparent path of the Moon, the necessary data having also been supplied from Russia. A comparison with Chacornac's map made it probable that two additional stars might be occulted, so on the next clear night these, as well as a few other stars that were to serve as guides for the reappearances, were connected micrometrically with the nearest star of the Pulkowa list. The phenomena were numbered 1 to 36, and the order in which the stars disappeared and reappeared indi-

* (76*a*) $\alpha = 11^h\ 12^m\cdot5$, $\delta = +3^\circ\ 51'\cdot8$.

cated on the map by writing the number of the disappearance below and that of the reappearance above each star. No use was made of the position angles for the reappearances, for it was to be expected that the Moon's light would not be sufficient to make the wires visible, and a constant artificial illumination would have been very objectionable. The known differences of declination between the stars, however, made it very easy by a series of simple operations to bring the spot where the reappearance was to be looked for into the centre of the field. Having selected for every star a conveniently situated reference star, and ascertained beforehand the readings of the micrometer screws corresponding to the difference of declination of these two stars, it remained to set the micrometer, illuminate the wires, bring the reference star on to its wire by the slow motion in declination, centre the other wire by means of the slipping-piece, remove the illumination, and turn the telescope by the slow motion in Right Ascension, until the edge of the Moon was in the centre of the field. Should the Moon not have been visible, the map would have permitted an estimate of the distance from the reference star.

Before the total phase the Moon was several times well seen between clouds, but not a trace of the stars could be made out. Gradually the clouds thickened, and hid the Moon for the first half of the total phase. The sky then began to clear up and eventually became perfectly cloudless.

During the totality the moon was very faint, and the copper tint, so conspicuous in other eclipses, was only seen occasionally, and then only feebly, and not uniformly spread over the Moon, but more intense in some parts than in others.

The following are the observations obtained during the latter half of the totality. The times were chronographed, as were also the observations for time. The places of the fundamental stars were taken from the *Berliner Jahrbuch*. Of the signals, three were noted as having been sent too late by about one second, the corresponding times have therefore been lessened by that quantity.

No. in the Pulkowa List.	Magnitude.	Phenomenon.	Observed Time by Chronograph.	Dun Echt Mean Time.
			h m s s	h m s
94	9–10	Disappearance	23 1 44·2 ±1	10 6 43·4
95	9·5	„	5 48·75–1	10 46·2
82	10	Reappearance	9 50·0	14 47·8
—	—	„	[10 10·1–1]	
85	10	„	22 18·0–1	27 12·8
81	9·5	„	22 59·35	27 55·0
109	8·8	Disappearance	25 56·55	30 51·8
Anon.	9	„	26 32·7	31 27·8

The corrections for the chronograph are the same as before.

Notes.

(94) Very difficult; uncertain to about ± 1ˢ.

(95) Very difficult; about 1ˢ late.

(82) This star reappeared suddenly, and was duly chronographed at $23^h\ 9^m\ 50^s{\cdot}0$, but it was hidden so quickly afterwards by clouds, as to leave a doubt of its having been seen. On its again becoming visible 20ˢ later, a second signal was given. There seems little doubt that the earlier record marks the actual reappearance.

(85) Observation fairly good, but sent the signal 1ˢ too late.

(81) Fairly good.

(109) Good. No. 108 was too faint to attempt an accurate observation; it disappeared almost immediately after 109.

Anon. (106*a*). Observation good. The approximate place from a single observation is

$$\alpha = 11^\circ\ 49'{\cdot}8,\ \delta = +4^\circ\ 7'{\cdot}6.$$

No. 107 was missed, and at the time of the disappearance of 106 the field of view was so strongly lit up by the partly illuminated Moon, that neither this star nor any of the others that had already reappeared could be seen.

Lord Crawford's Observatory,
Dun Echt:
1884, *Nov.* 13.

Total Eclipse of Moon, Oct. 4, 1884. By the Rev. S. J. Perry, F.R.S.

This eclipse was observed at Stonyhurst under very favourable circumstances, although the heavy dew interfered occasionally with the definition of the telescopes.

With a good binocular the Moon's disk was easily seen throughout the whole of totality, but to the naked eye there was no outline, the Moon having the appearance of a bright patch of light. The usual copper tint of the eclipsed Moon was not perceived except towards the close of the eclipse, and then it was only very slight. The general appearance in the binocular was that of a dull white ball, rather more brilliant at one part of the surface than elsewhere. The telescopes used were two Equatorials of 8 and 4 inches, a $9\frac{1}{2}$-inch Cassegrain, and a 7-inch Newtonian. The nature of the phenomena does not appear to admit of any great accuracy in the contacts.

Observations.	G.M.T.	Observer.	Instr.	Remarks.
	h m s			
First contact with shadow	8 15 20·4	S. P.	8-in.	Def. poor.
,,	8 16 31·0	J. R.	Cassegrain	,,
Beginning of totality	9 18 52	A. M.	4-in.	
,,	9 19 30·8	J. R.	Cassegrain.	
End of totality	10 46 6·3	,,	,,	A little late.
,,	10 46 31·5	S. P.	Binocular.	Fair.
Last contact with shadow	11 48 45·9	J. R.	Cassegrain.	
,,	11 48 52·1	A. C.	Newtonian.	
,,	11 49 54·2	S. P.	Binocular	Limb still charred.

The following stars were occulted :—

Döllen's No.	G.M.T. Disappearance.	G.M.T. Reappearance.	Observer.	Instr.	Remarks.
	h m s	h m s			
81	9 36 41·6	10 35 4·5	W. C.	8-in.	
81	9 36 53·2		A. M.	4-in.	Fair.
82	9 22 36·0		W. C.	8	Some uncertainty as to star.
85	9 24 23·8	10 31 38·5	W. C.	8	Good.
54	10 8 44·6		S. P.	8	
95	10 13 27·2		S. P.	8	
106	10 43 35 9		J. R.	Cassegrain.	
106	10 43 35·9		A. C.	4	Difficult.
109	10 36 50·2		J. R.		
109	10 36 57·2		A. C.		Poor.
Unknown.	9 35 6·3		W. C.		45° 10′ from N.

The initials stand for A. Müller, A. Cortie, W. Carlisle, J. Rooney, and S. Perry.

Stonyhurst Observatory:
1884, *Nov.* 8.

Occultations Observed during the Total Eclipse of the Moon, 1884, *October* 4, *at Harrow.* By Lieut.-Col. G. L. Tupman.

I used the 4½-inch Cooke Refractor which is fitted with position-circle and bar eyepiece, power 66, extremely convenient for occultations. Scarcely any of the stars on M. Döllen's list could be seen before the Moon was totally immersed, and, even during the period of the greatest obscuration, stars of about the tenth magnitude became extremely faint when within a second of arc of the Moon's limb, owing to the brightness of the latter. The

sky was quite clear and the air steady. An assistant called the seconds aloud from the mean-time chronometer Fletcher 1050. For the reappearances the bar was set to the position-angle and placed tangent to the Moon's limb a few seconds of arc off the limb. In spite of this precaution several reappearances were observed for which I could not be certain that I caught the exact emersion. The following are the only times for which I was sure of the phase:—

Star.	Green. M.T.	Phase.
	h m s	
63	9 2 7·0	Disap.
81	9 33 40·6	,,
69	9 39 35·1	Reap.
74	9 50 14·1	,,
94	10 6 54·1	Disap.
109	10 37 25·6	,,

The time was determined, with a small transit instrument lent to me by Mr. Latimer Clark, by observing high and low stars with reversed positions of the axis.

1884.	G.M.T.	Fletcher 1050 fast on G.M.T.	
	h m	s	
Sept. 30	9 57	27·3	1 star only
Oct. 3	9 38	23·76	8 stars
11	9 53	9·07	4 ,,

In the middle of the eclipse the chronometric correction has been taken $-22^{s}\cdot4$. The Greenwich mean time has been obtained by allowing the Geodetic Longitude $1^{m}\ 20^{s}\cdot0$ West, taken from the 6-inch ordnance survey.

The total light reflected from the Moon was compared directly with the stars as follows:—

At	h m 9 45	G.M.T. equal to $2\frac{1}{2}$ magnitude.
	10 8	,, 3 ,,
	10 30	,, 2 ,,
	10 44	,, Capella

The very slight ruddy tint during totality was not perceptible until a direct comparison with white stars was made.

The Total Eclipse of the Moon, 1884, *October* 4. By W. F. Denning.

A perfectly cloudless sky enabled the total lunar eclipse of October 4 to be well observed from this city.

The most noteworthy feature in connection with the phenomenon was that the Moon, at the total phase, appeared far less

luminous than usual. During the preceding eclipses of 1870, July 12, 1877, February 27 and August 23, all of which I observed, our satellite seemed considerably brighter than on the present occasion, and the colouring was more striking. The remarkable opacity of the shadow became evident when it had well encroached upon the Moon's eastern limb, and the fact was fully confirmed by the aspect of her disc during the subsequent stages of the eclipse.

The firmament grew as dark as on an ordinary night when the moon is entirely absent, and but for the indistinct outline of our satellite projected upon the dark background of the sky, there was nothing abnormal in the appearance of the heavens. Small stars could be distinguished with the customary readiness, and the Moon herself, high in the southern sky, looked like a large, ill-defined nebula with indeterminate outlines, or like a planet struggling feebly through very thick haze. Applying my 10-in. Reflector, power 60, her sharply circular contour, however, still admitted of satisfactory observation, and many leading features of the surface were recognised amid the prevailing gloom in which her landscape was involved.

As the Moon emerged from the umbra I believe the depth of the shading was perceptibly less intense than during the immersion. The blue tint so often observed in previous eclipses was distinctly present near the borders of the shadow, while in the more interior region the colouring developed into a dark reddish-brown; but the effect of the different hues and their variations during the progress of this eclipse were far less notable (owing to the extreme darkness of the umbra) than during the similar phenomena of 1870 and 1877 as I remember them.

I took advantage of the dark sky during the Moon's obscuration to examine the comet discovered by Wolf at Heidelberg on September 17. Its position was some 12° E. of the cluster of bright stars in the head of *Delphinus*; the comet was seen as a round nebulosity about 3′ diameter, and with a bright stellar nucleus.

Bristol:
1884, *Oct.* 8.

Abnormal Obscurity of the Moon in the late Eclipse. By the Rev. S. J. Johnson, M.A.

On the evening of October 4 there was a conspicuous return of the sunset after-glow that was common last winter. A peculiar state of the strata of our atmosphere might, therefore, indicate that something unusual was to be expected in the eclipse following.

At 8^h, penumbra barely perceptible with opera-glass.

At $8^h\ 12^m$, very decided.

$8^h\ 18^m\ 5^s$, shadow had reached *Grimaldi*.

At $9^h\ 7^m$, for the first time, a very small portion of the eclipsed disk, extending only 4′ or 5′ inwards, could be discerned through the telescope, this appearing of a dark slate colour—the same tint as is usually observed at the commencement of an eclipse.

At $9^h\ 10^m$, the whole of the lunar circle began to be seen through the telescope, but without a trace of the ordinary coppery redness.

$9^h\ 29^m\ 7^s$, reappearance of small star (time by sextant).

$10^h\ 2^m$, middle of totality. To the naked eye nothing could be seen but a faint nebulous spot. That the obscurity of the Moon arose from lack of illumination, not from fog or cloud, was seen by the fact that stars of small magnitudes above and below the lunar disk shone as distinctly as on an ordinary dark night. The exact appearance of the Moon at this time would be described by quoting Kepler's words verbatim about the eclipse of June (not December) 1620. "Luna difficillimè apparuit, emicuit tamen instar tenuissimæ nubeculæ, longè debilior quam viâ lacteâ, sine omni rubedine."

$10^h\ 8^m\ 21^s$, immersion of very faint star. Uncertain to 3 or 4 seconds.

$10^h\ 33^m\ 41^s$, star of magnitude $8\frac{1}{2}$ occulted. Appeared to linger for 4 seconds within the Moon's limb.

$10^h\ 39^m\ 28^s$, reappearance of a star.

$10^h\ 49^m\ 15^s$, sunlight breaking out.

The shadow left the Moon near the *Mare Fœcunditatis* about $11.48\frac{3}{4}$, the penumbra being conspicuous to the naked eye at 11.51. Thus, while the Moon did not completely disappear during totality (except to one correspondent), the peculiar features of the eclipse were the complete invisibility of the eclipsed orb until nine-tenths were covered, also subsequent to the total phase after one-tenth was uncovered. In this respect it seems similar to the earliest instance of the kind given in modern times, that observed by Kepler in 1601, an eclipse of nine-tenths of the Moon's disk. His words are (*Astronomiæ pars optica*), "Anno 1601 Decembri, tenuissimo cornu superstite, caliginosam tamen partem non vidi."

The usual explanation, that when the atmosphere is remarkably free from vapour the red rays would be absorbed, is hardly an adequate one.

(1.) Because the atmosphere was in an equal state of dryness on the occasion of the eclipse of July 12, 1870, when the Moon assumed the usual dull red or copper colour.

(2.) Because the last instance of the disappearance of the Moon was on June 10, 1816, when it could not be discerned even with telescopes, and this was one of the wettest summers in the century.

Melplash Vicarage,
Bridport: Oct. 11.

Observations of Comet 1884 (Barnard) made at the Royal Observatory, Cape of Good Hope.

(*Communicated by David Gill, LL.D., F.R.S., H.M. Astronomer.*)

The following observations were made with the 7-inch Equatorial and Repsold filar micrometer by Mr. W. H. Finlay, Chief Assistant. The comet was so situated that meridian observations of the comparison stars could always be secured with the transit circle within a few nights after their comparison with the comet. The observations are corrected for the effects of refraction.

The comet throughout presented the appearance of a small diffused nebulous mass. A nucleus was seen by glimpses on July 28, but the bright moonlight on following nights prevented more than an occasional suspicion of its existence. About the end of July the point of greatest condensation (in which the nucleus had been seen) was slightly towards the following part of the mass; this was the point observed. In August the appearance of the comet was reduced by moonlight to a small round mass slightly brighter towards the centre; the centre of this mass was observed. The comet presented a similar appearance in September, and was similarly observed. The comet, as a rule, was faint and difficult to observe in August, probably from its being projected on the Milky Way as a background. An apparent increase of brightness on September 15 and following days was very striking, compared with the appearance of the comet in the end of August.

Observations of Comet Pons-Brooks have been secured on forty-three nights from January 16 to April 29 inclusive, and will be published so soon as the meridian observations of the comparison stars have been completed.

Differences of R.A. and N.P.D. of the Comet and Comparison Stars, observed with the 7-inch Equatorial.

Date.	Cape Mean Time.	$\Delta\alpha$ ♂ − ✶	No. of Trans.	ΔN.P.D. ♂ − ✶	No. of Bisecs.	Comparison ✶
	h m s	m s		′ ″		
July 24	10 8 8·1	−0 13·0	4	+6 57·1	4	*a*
26	10 38 4·0	+4 30·38	4	−6 29·0	4	*b*
27	10 54 54·1	+0 10·09	16	−1 14·3	16	*c*
28	11 6 15·8	−0 14·11	16	+6 33·3	16	Stone 8897.
29	11 10 32·2	+1 0·99	16	−2 26·8	16	Stone 8913.
30	11 5 15·7	+0 47·41	16	+1 59·5	16	*d*
Aug. 1	10 19 53·3	−0 7·04	10	+1 31·0	6	*e*
5	9 35 49·5	+0 32·05	16	+0 53·5	16	*f*
6	9 53 49·7	+0 30·12	16	+2 18·8	16	*g*
7	10 10 18·4	+0 21·60	16	+1 31·6	16	*h*
8	10 10 5·0	−0 20·07	20	−0 46·7	16	*i*

Date.	Cape Mean Time.	$\Delta\alpha$ $\delta - *$	No. of Trans.	Δ N.P.D. $\delta - *$	No. of Bisecs.	Comparison *
	h m s	m s		′ ″		
Aug. 11	10 4 50·4	−0 22·80	20	−1 2·6	16	*k*
13	10 14 35·2	+0 23·13	20	−3 30·7	16	*l*
14	9 45 9·5	−0 21·98	12	−3 17·2	12	*m*
17	9 47 36·8	+0 29·46	16	+0 0·8	16	*n*
19	10 10 4·8	−0 17·79	15	−2 37·2	16	*o*
20	10 2 33·1			−0 9·5	8	*p*
20	10 12 46·7	−0 25·26	16			*p*
22	10 26 1·8	+0 10·08	16	+4 52·3	16	*q*
23	10 4 39·6	+0 35·86	16	+5 4·2	16	Yarnall 7433.
Sept. 15	10 19 31·8	+0 11·50	24	+5 7·9	18	O. Arg. S. 19534.
17	10 27 13·5	−0 51 09	16	+2 12·9	16	O. Arg. S. 19737.
21	9 44 44·1	−0 16·20	17	−2 26·6	12	Stone 10673.
22	10 12 12·9	+0 54·93	12	+0 7·3	16	O. Arg. S. 20039.

Notes.

July 24. Comet exceedingly faint and difficult; hazy.
28. Comet much easier to-night; distinct appearance of nucleus or condensation.
Aug. 1. Comet very faint: bright moonlight.
5. Moon very bright; but fair observations.
7. Bright moonlight; air very damp and hazy; comet very faint.
13. Comet faint.
19. Comet very faint; very difficult.
20. Comet exceedingly faint, scarcely possible to observe at all.
22. Fair observations.
Sept. 15. Comet much easier, and brighter than when last observed.

The following Table gives the differences of Right Ascension and N.P.D. between the comparison stars and brighter stars observed with the Equatorial.

Star.	Mag.	R.A. = *	N.P.D. = *	Compared with *.
		m s	′ ″	
a	9½	+2 5·10	−1 30·8	*a′*
b	9	−4 22·0	−5 49·5	*b′*
c	10	−2 57·55	+7 51·9	Stone 8897.
c	10	−4 19·75	−0 52·0	Stone 8913.
d	7½	+2 55·0	−4 54·6	Stone 8913.
e	10	+0 13·10	+3 43·1	*e′*
f	10	+2 32·85	−0 45·7	Stone 9061.
h	9½	+3 28·30	−1 55·0	*g*
h	9½	−4 2·95	+0 35·5	*i*
k	10	+0 15·12	−7 10·2	*k′*
k′	8½	+0 3·10	−7 40·7	Stone 9295.
o	10½	−0 26·90	−2 33·5	*o′*

Adopted Right Ascensions and North Polar distances of Stars observed with the Comet.

Star.	Mag.	Mean R.A. 1884·0.	Mean N.P.D. 1884·0.	Date of Comp. with ♂	Reductions to App. Place. R.A.	Reductions to App. Place. N.P.D.	Authority for Mean Place.
		h m s	° ′ ″		s	″	
a	9½	16 5 39·80	127 7 47·3	July 24	+3·83	+ 5·7	Measures with Equatorial.
a′	8½	16 3 34·70	127 9 18·1	24	+3·83	+ 5·7	3 Meridian observations Cape 1884
b	9	16 5 40 52	127 21 57 9	26	+3·85	+ 5·2	Measures with Equatorial.
b′	7½	16 10 2·52	127 27 47·4	26	+3·85	+ 5·2	3 Meridian observations.
c	10	16 12 27·70	127 16 44·8	27	+3·84	+ 5·0	Measures with Equatorial.
Stone 8897	7	16 15 24·88	127 8 52·4	27, 28	+3·84	+ 4·7	Stone 8897.
Stone 8913	6	16 16 47·64	127 17 37·2	27, 29	+3·82	+ 4·7	Stone 8913.
d	7½	16 19 42·64	127 12 42·6	30	+3·82	+ 4·7	Measures with Equatorial.
e	10	16 26 8·91	127 11 44·7	Aug. 1	+3·84	+ 3·8	,, ,,
e′	8	16 25 55·81	127 8 1·6	1	+3·84	+ 3·8	2 Meridian observations.
Stone 9061	7	16 34 59·59	127 6 55·4	5	+3·83	+ 3·0	Stone 9061.
f	10	16 37 32·44	127 6 9·7	5	+3·83	+ 3·0	Measures with Equatorial.
g	7½	16 40 50·42	127 2 23·1	6	+3·84	+ 2·5	2 Meridian observations.
h	9½	16 44 18·34	127 0 29·3	7	+3·84	+ 2·1	Measures with Equatorial.
i	7½	16 48 20·93	126 59 54·7	8	+3·85	+ 1·8	3 Meridian observations.

Star.	Mag.	Mean R.A. 1884 o.	Mean N.P.D. 1884·0.	Date of Comp. with ♂	Reductions to App. Place. R.A.	Reductions to App. Place. N.P.D.	Authority for Mean Place.
		h m s	° ′ ″		s	″	
Stone 9295	6½	16 58 30·01	127 3 58·2	Aug. 11	+3·86	+ 0·9	Stone 9295.
k'	8½	16 58 33·17	126 56 17·1	11	+3·86	+ 0·9	2 Meridian observations.
k	10	16 58 48·29	126 49 6·9	11	+3·86	+ 0·9	Measures with Equatorial.
l	9½	17 5 18·69	126 42 15·1	13	+3·85	+ 0·2	2 Meridian observations.
m	9	17 9 41·92	126 36 43·1	14	+3·85	− 0·2	3 ,,
n	9½	17 20 14·28	126 14 55·0	17	+3·84	− 1·2	2 ,,
o	10½	17 28 54·91	126 2 44·1	19	+3·84	− 2·1	Measures with Equatorial.
o'	8½	17 29 21·81	126 5 17·6	19	+3·84	− 2·1	2 Meridian observations.
p	9	17 33 1·39	125 52 26·2	20	+3·83	− 2·4	2 ,,
q	8	17 40 30·55	125 29 35·7	22	+3·82	− 3·2	2 ,,
Yarnall 7433	8½	17 44 5·16	125 19 53·4	23	+3·81	− 3·5	Cape and Washington.
O. Arg. S. 19534	8½	19 19 48·86	119 32 10·0	Sept. 15	+3·59	−12·2	O. Arg. and 2 Cape Merid. observs.
,, 19737*	8½	19 28 48·23	118 55 17·6	17	+3·57	−13·0	2 Meridian observations.
,, 19997	8½	19 43 37·70	117 38 28·8	21	+3·52	−14·2	Stone 10673.
,, 20039	7½	19 46 17·93	117 14 26·5	23	+3·50	−14·4	O. Arg., Wash., 8540 & Cape Mer.

Resulting Places of the Comet.

Date.	Cape M.T.	R.A.	Log. par. factor.	N.P.D.	Log. par factor.
	h m s	h m s		° ′ ″	
July 24	10 8 8·1	16 5 30·56	8·6170	127 14 49·1	8·5798
26	10 38 4·0	16 10 14·75	8·6675	127 15 34·1	8·8389
27	10 54 54·1	16 12 41·63	8·7033	127 15 35·5	8·9868
28	11 6 15·8	16 15 14·61	8·7251	127 15 30·4	9·0719
29	11 10 32·2	16 17 52·45	8·7340	127 15 15·1	9·1072
30	11 5 15·7	16 20 33·87	8·7267	127 14 46·8	9·0792
Aug. 1	10 19 53·3	16 26 5·69	8·6435	127 13 19·6	8·5911
5	9 35 49·5	16 38 8·32	8·5302	127 7 6·2	7·6990
6	9 53 49·7	16 41 24·38	8·5798	127 4 44·4	8·4472
7	10 10 18·4	16 44 43·78	8·6325	127 2 3·0	8·7076
8	10 10 5·0	16 48 4·67	8·6325	126 59 9·8	8·7076
11	10 4 50·4	16 58 29·35	8·6222	126 48 5·2	8·6902
13	10 14 35·2	17 5 45·67	8·6464	126 38 44·6	8·8195
14	9 45 9·5	17 9 23·79	8·5798	126 33 25·7	8·5315
17	9 47 36·8	17 20 47·58	8·5763	126 14 54·6	8·5798
19	10 10 4·8	17 28 40·96	8·6345	126 0 4·9	8·8325
20	10 12 46·7	17 32 39·96	8·6395	125 52 10·9	8·7709
22	10 26 1·8	17 40 44·45	8·6665	125 34 24·9	9·0000
23	10 4 39·6	17 44 44·83	8·6170	125 24 54·1	8·8513
Sept. 15	10 19 31·8	19 20 3·95	8·6138	119 37 5·7	9·2355
17	10 27 13·5	19 28 0·71	8·6263	118 57 17·5	9·2718
21	9 44 44·1	19 43 25·02	8·5132	117 35 48·0	9·2253
22	10 12 12·9	19 47 16·36	8·5866	117 14 19·4	9·2945

The comet was also observed with the transit-circle by Mr. Finlay on August 14 and 16, with the following results :—

Aug. 14	7 34 48·8	17 9 6·19	126 33 57·5	8·6812
16	7 34 26·0	17 16 36·39	126 22 6·6	8·6435

The Orbit of Barnard's Comet, 1884. By J. Morrison, M.D., Ph.D., Assistant on the American Ephemeris, Washington, D.C.

From the numerous observations of this comet, already published, I select for the purpose of computing elliptic elements the following observations made at Cambridge, Mass., Nice, and Washington respectively :—

Washington M.T.	α	δ
July 25·371990	242° 4′ 4″·5	−37° 15′ 32″·0
Aug. 24·124442	267 10 42·3	−35 15 30·4
Sept. 23·339919	297 55 9·3	−26 49 50·6

From these positions I obtain by the usual methods the following system of elliptic elements :—

Epoch	1884, Sept. 24·5 Wash. M.T.	
M	7° 13′ 19″·52	Mean Equinox of 1884·0.
ω	300 57 44·43	
Ω	5 11 23·56	
i	5 27 18·94	
φ	35 37 2·50	
log *q*	0·1069968	
log *a*	0·4862043	
log μ	2·8207001	
P	1958·41 days.	

The residuals for the middle place are zero, and for the following dates the difference between the computed and observed places is as small as can be expected, considering the great difficulty in observing accurately so faint an object :—

Wash. M.T.	*d*λ cos β.	C−O. *d*β.	log. Δ.
1884, Aug. 12·361652	+ 6″·52	− 3″·21	9·65375
Sept. 15·408454	+ 9 85	− 8 09	9·74018
Oct. 11·318804	+30·91	−10·62	9·86241
14·365442	+21·56	+15·71	9·87849

Observations of Comet Barnard, 1884. By John Tebbutt.

The telegram announcing this comet was received from the Melbourne Observatory on July 23, and the comet itself was found on the following evening. Throughout the whole period of observation the comet was excessively faint, and on August 22 was seen with the greatest difficulty. I have made the accompanying observations with the square bar-micrometer on the 4½-in. Equatorial, the whole series being carefully corrected for defective orientation of the micrometer and for proper motion. The refraction corrections, owing to the great altitude at which the comet was observed, are insensible. In those cases where the comparison stars were found in Stone's *Cape Catalogue*, the precessions and secular variations of that catalogue were employed in bringing up the star's mean places to 1884·0. In all other cases the precessions have been calculated for the mean epochs by means of Peter's elements.

Apparent Places of Comet Barnard, 1884.

Windsor M. T.				R.A.			Log $\frac{p}{P}$.	N.P.D.			Log $\frac{q}{P}$	No. of Comps.	Comp. Star.
d	h	m	s	h	m	s		°	′	″			
July 24	9	38	34	16	4	41·06	+8·4868	127	14	23·7	−8·1770	4	1
24	9	38	34	16	4	41·10	+8·4868	127	14	26·3	−8·1770	4	2
27	14	24	36	16	12	9·41	+8·8388	127	15	21·3	+9·7125	3	3
27	14	24	36	16	12	8·99	+8·8388	127	15	18·8	+9·7125	3	4
28	9	13	27	16	14	6·42	+8·4054	127	15	36·5	−8·5057	10	4
28	10	40	7	16	14	15·43	+8·6782	127	15	25·2	+8·8403	5	3
28	10	40	7	16	14	15·43	+8·6782	127	15	27·4	+8·8403	5	4
31	9	41	34	16	22	9·77	+8·5342	127	14	24·5	−7·2041	7	3
31	9	41	34	16	22	9·67	+8·5342	127	14	25·8	−7·2041	7	4
31	9	41	34	16	22	9·03	+8·5342					7	5
31	9	41	34	16	22	9·51	+8·5342	127	14	24·9	−7·2041	7	6
Aug. 2	9	8	57	∗	+	2 2·83	+8·4123	∗	+	12 42·3	−8·4768	6	7
2	9	8	57	∗	+	1 49·13	+8·4123	∗	+	4 27·5	−8·4768	6	8
2	9	8	57	∗	−	1 24·31	+8·4123	∗	+	18 23·8	−8·4768	6	9
2	9	8	57	16	27	48·54	+8·4123	127	12	34·0	−8·4768	6	10
2	9	8	57	16	27	48·29	+8·4123	127	12	34·5	−8·4768	6	11
4	8	40	9	∗	+	4 33·37	+8·2563	∗	+	15 37·8	−8·6801	3	9
4	8	40	9	16	33	46·12	+8·2563	127	9	48·9	−8·6801	3	10
6	10	26	23	16	40	16 59	+8·6683	127	5	37·4	+8·8140	7	10
6	10	26	23	16	40	16·87	+8·6683	127	5	35·4	+8·8140	7	12
6	10	26	23	∗	−	0 37 33	+8·6683	∗	+	3 10·1	+8·8140	7	13
6	10	26	23	16	40	16·78	+8·6683	127	5	34·3	+8·8140	7	14
8	9	29	56	∗	+	5 50·56	+8·5167	∗	−	2 6·6	−7·4478	10	13
8	9	29	56	16	46	44·46	+8·5167	127	0	17 0	−7·4478	10	14
8	9	29	56	16	46	44·35	+8·5167	127	0	21 0	−7·4478	10	15
9	9	13	4	16	50	5·63	+8·4532	126	57	8 6	−8 2477	7	16
9	9	13	4	16	50	5·23	+8·4532	126	57	8·5	−8·2477	7	17
10	8	26	9	16	53	25·60	+8·1767	126	53	51·8	−8·6862	2	16
10	8	26	9	16	53	25·28	+8·1767	126	53	52·6	−8·6862	2	17
11	8	34	13	16	56	57·63	+8·2434	126	50	0·6	−8·6347	2	17
11	9	15	13	16	57	3·82	+8·4652	126	49	39·0	−8·1093	12	16
12	8	41	31	17	0	33 76	+8·2951	126	45	40·2	−8·5730	6	16
13	9	36	37	17	4	18·66	+8·5447	126	40	35·4	+8·0738	6	17
14	8	56	17	17	7	54·60	+8·3817	126	35	43·2	−8·3816	4	18
14	9	5	13	17	7	55·56	+8·4248	126	35	38·5	−8·2294	3	19
16	10	4	27	17	15	35·12	+8·6236	126	23	42·0	+8·7040	10	19
16	10	4	27	17	15	35 37	+8·6236	126	23	42·2	+8·7040	10	18
18	9	6	0	17	23	8·18	+8·4286	126	10	38·5	−7·9525	10	19
22	10	6	32	17	39	12·28	+8·6246	125	37	39·3	+8·8118	12	20
22	10	6	32	17	39	12·01	+8·6246	125	37	41·4	+8·8118	12	21

Adopted Mean Places of the Comparison Stars for 1884·0, *with the Reductions to the Apparent Places for the Dates of Observation.*

Star.	R.A.	Reduction.	N.P.D.	Reduction.	Authorities.
	h m s	″	° ′ ″	″	
1	15 56 57·72	+3·80	127 32 16·4	+ 6·5	Wash. Mural Cir. Zone 24, 16; Wash. Cat. 1860, 6623; Cape Cat. 1880, 8727.
2	15 57 2·14	+3·80	127 29 40·9	+ 6·4	Wash. Mural Cir. Zone 24, 17; Wash. Cat. 1860, 6624; Cape Cat. 1880, 8730.
3	16 10 2·58	+3·84	127 27 45·1	+ 5·2	Wash. Mural Cir. Zone, 24, 18.
4	16 16 47·65	+3·87	127 17 36·8	+ 4·5	Wash. Mural Cir. Zone 24, 19; Wash. Cat. 1860, 6768; Cape Cat. 1880, 8913.
4	16 16 47·65	+3·86	127 17 36·8	+ 4·6	Ditto. ditto.
3	16 10 2·58	+3·83	127 27 45·1	+ 5·3	Wash. Mural Cir. Zone, 24, 18.
4	16 16 47·65	+3·86	127 17 36·8	+ 4·6	Wash. Mural Cir. Zone 24, 19; Wash. Cat. 1860, 6768; Cape Cat. 1880, 8913.
3	16 10 2·58	+3·78	127 27 45·1	+ 5·4	Wash. Mural Cir. Zone, 24, 18.
4	16 16 47 65	+3·81	127 17 36·8	+ 4·7	Wash. Mural Cir. Zone 24, 19; Wash. Cat. 1860, 6768; Cape Cat. 1880, 8913.
5	16 15 24·88	+3·80			Cape Cat. 1880, 8897.
6	16 19 42·39	+3·83	127 12 39·2	+ 4·4	Anonymous = 9 mag. Equatorial comparisons.
7	16 25 41·9	+3·82	126 59 49	+ 3·8	,, = 8 mag. ,, ,,
8	16 25 55·9	+3·83	127 8 3	+ 3·8	,, = 7½ mag. ,, ,,
9	16 29 8·8	+3·84	126 54 8	+ 3·4	,, = 8½ mag. ,, ,,
10	16 31 19·43	+3·86	126 58 56·7	+ 3·2	Wash. Cat. 1860, 6851; Cape Cat. 1880, 9019.
11	16 33 0·68	+3·86	126 55 27·7	+ 3·0	,, 1860, 6864; ,, 1880, 9046.
9	16 29 8·8	+3·81	126 54 8	+ 3·5	Anonymous = 8½ mag. Equatorial comparisons.
10	16 31 19·43	+3·83	126 58 56·7	+ 3·3	Wash. Cat. 1860, 6851; Cape Cat. 1880, 9019.
10	16 31 19·43	+3·79	126 58 56·7	+ 3·3	Ditto. ditto.
12	16 34 59·59	+3·82	127 6 55·4	+ 3·0	Cape Cat. 1880, 9061.

Star.	R.A.	Reduction.	N.P.D.	Reduction.	Authorities.
	h m s	″	° ′ ″	″	
13	16 40 50·2	+3·85	127 2 24	+ 2·4	Anonymous = 8 mag. Equatorial comparisons.
14	16 43 10·93	+3·88	127 18 43·2	+ 2·3	Wash. Cat. 1860, 6943; Cape Cat. 1880, 9128.
13	16 40 50·2	+3·82	127 2 24	+ 2·5	Anonymous = 8 mag. Equatorial comparisons.
14	16 43 10·93	+3·84	127 18 43·2	+ 2·3	Wash. Cat. 1860, 6943; Cape Cat. 1880, 9128.
15	16 48 20·77	+3·86	126 59 54·5	+ 1·8	,, 1860, 6997.
16	16 58 29·89	+3·90	127 3 58·2	+ 0·8	,, 1860, 7082; Cape Cat. 1880, 9295,
17	16 58 32·80	+3·89	126 56 16·8	+ 0·8	,, 1860, 7083.
16	16 58 29·89	+3·88	127 3 58·2	+ 0·8	,, 1860, 7082; Cape Cat. 1880, 9295.
17	16 58 32·80	+3·88	126 56 16 8	+ 0·8	,, 1860, 7083.
17	16 58 32·80	+3·86	126 56 16·8	+ 0·9	,, 1860, 7083.
16	16 58 29·89	+3·87	127 3 58·2	+ 0·9	,, 1860, 7082; Cape Cat. 1880, 9295.
16	16 58 29·89	+3·85	127 3 58·2	+ 0·9	,, 1860, 7082; ,, 1880, 9295.
17	16 58 32·80	+3·83	126 56 16 8	+ 0·9	,, 1860, 7083.
18	17 21 5·19	+3·92	126 40 46·8	− 1·3	Wash. Mural Cir. Zone 16, 58; Cape Cat. 1880, 9518.
19	17 19 57·61	+3·91	126 25 24·5	− 1·3	,, ,, 16, 57.
19	17 19 57·61	+3·87	126 25 24·5	− 1·2	,, ,, 16, 57.
18	17 21 5·19	+3·88	126 40 46·8	− 1·2	,, ,, 16, 58; Cape Cat. 1880, 9518.
19	17 19 57·61	+3·83	126 25 24·5	− 1·1	,, ,, 16, 57.
20	17 40 26·85	+3·84	125 51 1·0	− 3·1	Wash. Merid. Trans. Zone 44, 15; Wash. Cat. 1860, 7403; Cape Cat. 1880, 9681.
21	17 45 10·03	+3·85	125 35 30·6	− 3·6	Wash. Merid. Trans. Zone 44, 20; Wash. Obs. 1873, 476; Wash. Obs. 1874, 343; Cape Cat. 1880, 9734.

Private Observatory,
Windsor, N.S. Wales:
1884, *Sept.* 10.

Approximate Elliptic Elements of Comet 1884 (*Barnard*).

By W. H. Finlay, B.A.

I computed a parabolic orbit for this comet in August, but was unable to represent the middle place satisfactorily. As a similar result was found in Europe, and as M. Stechert's ephemeris in *Astr. Nach.*, No. 2609, showed large discordances from my later observations, I have computed elliptic elements with the following result. The observations used, viz. July 27, August 22, and September 17, were corrected for parallax from the parabolic orbit. The approximations to Q were not carried as far as perhaps they should have been, but the approximation was quite close enough to show whether the comet was moving in an ellipse, and if so, to give a very fair value of the periodic time.

τ	August 16^d·50950 G.M.T.	
π	306° 3′ 40″	Mean Equinox and Elliptic 1884·0.
Ω	4 54 1	
ι	5 30 36	
log. a	0 5017524	
ϕ	36 34 31	
μ	627″·159	
Period	5·6615 years	

These elements leave a discordance $c-o$ in the middle place of $-8''$ *in longitude and* $-1''$ *in latitude.* The month of October, since the Moon drew away from the evening sky, has been completely clouded until last night, October 14, when I secured a fine comparison of the comet with Arg. Oeltz. 21151. This observation compared with the above elements gives the discordance $(c-o)$.

$$d\alpha \cos\delta = -5^{s}\cdot0$$

$$d\delta = -11''\cdot0$$

Royal Observatory,
Cape of Good Hope:
1884, *Oct.* 15.

Errata in Vol. XLIII., No. 1, November 1882.

(*Communicated by the Astronomer Royal.*)

Observations of Comet a, 1882, S.P. with the Transit Circle.

(Page 27.)

		h m s		h m s
May 12	Greenwich Mean Solar Time, *for*	8 52 15	*read*	8 52 13
	R.A. ... ... „	0 14 19·68	„	0 14 17·46
15	R.A. ... ... „	1 26 20·62	„	1 26 19·51
19	Greenwich Mean Solar Time „	10 48 58	„	10 49 0
	R.A. ... ... „	2 38 58·01	„	2 38 59·06

The corrections on May 12 and 15 are owing to errors of computation in taking the means of the wires, the usual practice of neglecting the minutes and decades of seconds in the summation of the wires having been followed in this case, to which it is not applicable on account of the uncertainty of observation of the middle wire exceeding 1ˢ.

Observations of Comet c, 1884 (Wolf), made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The observations with the East or Sheepshanks Equatorial and the Lassell Reflector were made by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination.

Observations of Comet c, 1884, with the Transit Circle.

1884.	Greenwich Mean Solar Time.	Observer.	R.A.	N.P.D. (corrected for Refraction and Parallax).
d	h m s		h m s	° ′ ″
Sept. 25	8 57 39	J. P.	21 17 57·74	69 49 14·21
27	8 51 9	L.	21 19 19·24	70 45 12·75
28	8 47 58	A. D.	21 20 4·16	71 13 55·99

September 25.—A very faint object, diffused at edges but slightly condensed towards centre. Object confused with illuminated wires. The observation of N.P.D. very rough, the horizontal wire being unilluminated.

September 27.—Extremely faint patch of light, brighter towards centre. Observation of N.P.D. not very good.

September 28.—Fairly bright in dark field with nucleus.

Observations of Comet c, 1884, *with the East Equatorial, aperture 6·7 inches.*

Observer, A. D.

Greenwich Mean Solar Time. 1884.	♂ − ✶ R.A.	Corr. for Par. and Refrac. in R.A.	♂ − ✶ N.P.D.	Corr. for Par. and Refrac. in N.P.D.	No. of Comp.	Apparent R.A.	Apparent N.P.D.	
d h m s	m s	s	′ ″	″		h m s	° ′ ″	
Sept. 28 7 54 23	−1 5·60	−0·10	+5 10·8	−5·1	4	21 20 1·08	71 12 15·6	*a*

Comet very faint but with stellar nucleus; moon bright; clouds passing.

Observations of Comet c, 1884, *with the Lassell Reflector, aperture 24 inches.*

Greenwich Mean Solar Time. 1884.	♂ − ✶ R.A.	Corr. for Par. and Refract. in R.A.	♂ − ✶ N.P.D.	Corr. for Par. and Refract. in N.P.D.	No. of Comp.	Apparent R.A.	Apparent N.P.D.	
			Observer, H.					
d h m s	m s	s	′ ″	″		h m	° ′	
Nov. 7 9 38 51	−1 23·94	+0·26	+0 11·1	−7·5	4			*b*
9 45 17	+1 24·01	+0·26	−3 56·4	−7·7	2			*c*
9 57 18	+4 30·32	+0·27	−2 14·3	−7·6	2	22 23 54·56	89 9 58·8	*d*
10 3 56	+0 54·79	+0·29	−5 0·2	−7·8	1	22 23 55·87	89 10 23·8	*e*
9 57 18	+3 14·66	+0·28	−3 43·3	−7·7	2			*f*
			Observer, A. D.					
Nov. 8 9 16 47	+0 22 78	+0·22	−2 11·8	−7 6	4	22 26 2 91	89 30 42·3	*g*
9 27 51	−0 16 64	+0·24	−5 36·2	−7·8	3	22 26 7·80	89 28 53·2	*h*
9 42 53	+1 37·19	+0·24	+3 28·3	−7·3	3	22 26 5·30	89 29 11·7	*i*

Assumed Mean Places of the Comparison Stars.

Star.	Star's Name.	R.A. 1884·0	N.P.D. 1884·0	
		h m s	° ′ ″	
a	B. F. 2925	21 21 3·28	71 7 35·1	3 meridian observations at Greenwich.
b	Anonymous			
c	,,			
d	π Aquarii	22 19 21·10	89 12 38·8	Greenwich 7 year Catalogue, 1864.
e	Arg. Z. + 0° − 4878	22 22 57·92	89 15 49·6	Bonn. Obs. vol. vi.
f	Anonymous			
g	Arg. Z. + 0° − 4887	22 25 36·97	89 33 19·8	Bonn. Obs. vol. iii.
h	Arg. Z. + 0° − 4889	22 26 21·27	89 34 55·1	,,
i	Arg. Z. + 0° − 4884	22 24 24·94	89 26 9·0	,,

November 7.—Comet very faint at last observation. Moon rising.

November 8.—Some difficulty in finding comet as thin clouds were constantly coming up; but comet bright with nucleus when the sky was clear. A small star seen through the nebulous envelope. Wires seen with difficulty, transits rough in consequence.

The observations are corrected for parallax and refraction. The initials A. D., L., H., and J. P. are those of Mr. Downing, Mr. Lewis, Mr. Hollis, and Mr. J. Power.

Occultations of Stars by the

Observed at the Davidson Observatory, San Francisco, California,

(*Communicated by*

No.	Date 1883.	Star.	Estimated Mag.	Phase.	Obs.	Telescope. Ap. inch.	Power diam.	Chronom.
1	Jan. 14	Yarnall 413	$7\frac{1}{2}$–8	Im.	C.B.H.	6·4	90?	Sid. 223
2		Anon.	$8\frac{1}{2}$–9	„	„	6·4	90	„
3		Arg. + 7° : 119 (?)	$7\frac{1}{2}$–8	„	„	6·4	90	„
4		Anon.	8–$8\frac{1}{2}$	„	„	6·4	90	„
5	15	Arg. + 11° : 218 (?)	8	„	„	6·4	90	„
6		Arg. + 11° : 217 (?)	$8\frac{1}{2}$	„	„	6·4	90	„
7	Apr. 16	14 Sextantis	—	„	„	6·4	120	„
8	May 10	λ Geminorum	—	„	„	6·4	90	„
9	June 12	Anon.	$8\frac{1}{2}$	„	„	6·4	150	Sid. 3479
10		B.A.C. 4020	$7\frac{1}{2}$	„	„	6·4	150	„
11	Sept. 11	ϕ^1 Sagittarii	—	„	G.F.D.	6·4	40	„
12		ϕ^1 Sagittarii	—	„	C.B.H.	3·0	105	Sid. 223
13	12	(R.A. 20^h 10^m $\delta - 15°{\cdot}6$)	$8\frac{1}{2}$	„	„	6·4	90	Sid. 3479
14		β^1 Capricorni	—	„	G.D.	6·4	120	„
15		β^2 Capricorni	—	„	„	6·4	120	„
16		β^2 Capricorni	—	„	C.B.H.	3·0	40	Sid. 223
17	Nov. 4	(R.A. 18^h 35^m $\delta - 18°{\cdot}7$)	$9\frac{1}{2}$–10	„	„	6·4	—	M.T. 5038

(*a*) Hazy, blurred, and tremulous, but disappearance sharp. Felt a slight doubt as to whether * disappeared *just* previous to 59·5 beat or 60·0 beat.

On a New Solar Eyepiece. By Adam Hilger.

Several forms of eyepieces have been contrived for the purpose of diminishing the light and heat from the Sun in a degree sufficiently great to permit of the using of large apertures without inconvenience to the observer.

One of the best known prisms is that which was devised by Sir John Herschel, in which a prism is used whose first surface is placed at an angle of 45°; only about one-twentieth part of its light is reflected on to the eye, the other nineteen-twentieths passing out of the telescope.

In 1871 Professor Pickering (*Proceedings American Academy of Arts and Sciences*, Feb. 14, 1871) devised an ingenious modification of this plan by cementing a second prism on to the first prism by a substance whose index of reflection is very nearly equal to that of the glass. In consequence an exceedingly small

Moon, 1883. By George Davidson.

during the year 1883. Lat. 37° 47′ 24″·1 N., and Long. 122° 25′ 37″·6 W.

the Secretaries.)

Chron. Time as recorded.	Correction to Chron.	Observations. Local Mean Time.	Local Sid. Time.	Remarks.
h m s	m s	h m s	h m s	
3 23 40·8	−3 53·55	7 42 44·5	3 19 47·2	Good. ✶ about 5′ S. of centre
4 6 38·5	−3 53·62	8 25 35·2	4 2 44·9	Pretty good. ✶ nearly at centre.
4 15 28·3	−3 53·63	8 34 23·5	4 11 34·7	Good. ✶ about 8″ S.
4 17 21·4	−3 53·64	8 36 16·3	4 13 27·8	Good. ✶ about 11′ N. of centre
1 55 3·5	−3 55·90	6 10 23·5	1 51 7·6	✶ about 10′ S. of centre.
1 58 46·9	−3 55·90	6 14 6·3	1 54 51·0	✶ about at centre.
11 37 3·4	−1 22·67	9 55 33·3	11 35 40·7	Very good.
12 30 59·45	−0 24·09	9 15 56·3	12 30 34·5	(*a*)
14 10 25·7	−0 15·40	8 45 30·8	14 10 10·3	Nearly at centre.
14 25 10·0	−0 15·40	9 0 12·6	14 24 54·6	About 5′ N. of centre.
21 27 48·8	+0 3·40	10 4 13·2	21 27 52·2	G.D. marked time. Recorded 48ˢ·9 − 0ˢ·1.
21 28 38·2	−0 46·85	10 4 12·4	21 27 51·4	? 38ˢ·7 (*b*)
21 41 16·0	+0 4·63	10 13 43·5	21 41 20·6	✶ *just* S. of centre.
0 6 17·2	+0 4·75	12 38 21·1	0 6 22·0	
0 [14]50·1	+0 4·76	12 45 52·8	0 13 54·9	Minutes assumed 13.
0 14 43·3	−0 48·46	12 45 52·8	0 13 54·8	
6 52 38·8	+5 58·18	6 58 37·0	21 54 39·3	✶ very faint, obsn. doubtful. Not in Wash. zones.

(*b*) I heard G.F.D.'s call, and disappearance to my eye happened 0ˢ·2 to 0ˢ·3 before the sound reached me, or at 48ˢ·5 on his chronometer. Carried beats 6 or 7 minutes, and mine may have been one beat in error.—C.B.H.

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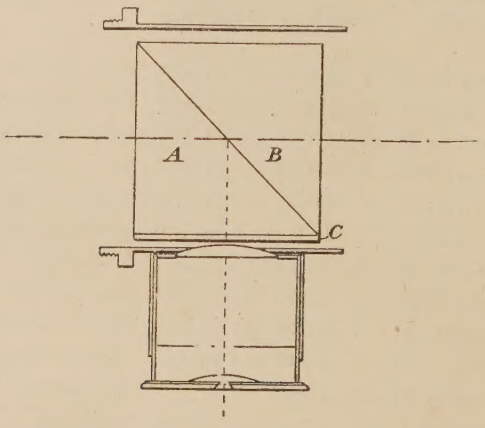
fraction of the total light is reflected, nearly all the light and heat passing out of the telescope.

It is obvious, however, that in this arrangement there is the drawback of the existence of two reflections, one at the surface of the cementing layer, and a second reflection at the surface of the second prism.

Professor Pickering relied upon the extreme thinness of the layer of Canada balsam, which was the cement used, for the sensible superposition, and merging into one of the two reflections, so that the definition should not be impaired by any noticeable duplication of the image.

I have constructed several of these eyepieces, but I have not been able to make the cementing layer so thin, but that with high powers the definition begins to break down, being sensibly impaired by the double reflection. In the new form of eye-

piece which I have now the honour to submit to the Society I have succeeded in doing away with the second reflection, and at once restoring the quality of the definition to that which the telescope is capable of giving, and also at the same time reducing to nearly one-half the amount of light reflected to the eye. I



have accomplished this improvement by making the second prism B of solid Canada balsam contained in a glass cell, of which the surface of the first prism forms one side. There is consequently one reflection only, where the first prism A meets the solid Canada balsam at the angle of 45°.

The first prism is made of glass, whose index of refraction is very near that of the solid balsam.

The amount of light reflected is so small that large apertures may be used without any further protection to the eye.

To reduce still more the amount of light, especially if very large apertures were used, I cemented a thin plate of neutral tint glass C on the surface of the prism A, where the light emerges after reflection. An eyepiece of pale neutral tint glass I found also to produce the same effect as the thin parallel neutral tint plate.

I consider the eyepiece will be found most generally useful in the form which it is described in this paper, with a pale neutral tint plate permanently cemented to the face of the prism.

The two principal advantages which I venture to claim for this new eyepiece are:—

1st. No impairment of definition when high powers are used.

2nd. A further diminution of the small fraction of light reflected by Professor Pickering's eyepiece to nearly one-half.

Erratum.

Vol. XLIV., page 452, line 11 from below, *for* 20″·25, *read* 12″·25.